JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

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EDITORIAL.

NOTICE.—The publication of the JOURNAL is made under the direction of the Editor and the Committee of Publication, who endeavor to exercise such supervision of its articles, as will prevent the inculcation of errors, the advocacy of special interests, and will produce an instructive and entertaining periodical; but it must be recognized that the Franklin Institute is not responsible, as a body, for the statements and opinions advanced in its pages.

Safety Boilers.—Two explosions of the Howard tubulous boilers have recently occurred in England, resulting in loss of life and property, as usual from similar disasters to other kinds of boilers. The evidence before the coroner at the inquest for one of these explosions is reported in the London *Engineer* of December 31, 1875, to which paper, those who desire full particulars are referred. Mr. Lavington E. Fletcher, Chief Engineer to the Manchester Steam Users' Association, in his evidence says: "The Howard patent safety boiler consists of a number of pipes, in which the steam is generated, the pipes sometimes set vertically and sometimes horizontally, or nearly so."

As stated by Mr. Fletcher, there are two entirely different types of Howard safety boiler. The original construction consisted of a number of rows of 6, 8 or 10-inch vertical wrought iron tubes, 4 feet or

so in length, with upper ends closed (the steam being removed from the vertical tubes by a small pipe connection at the closed ends), and lower ends joined to lines of cast iron bed pipes, which lines of bed pipes were also joined together by a cross bed pipe at one end; the fire was applied below the bed pipes and the heat made to circulate among the vertical tubes. This type of boiler was found to have the usual faults of a cast iron boiler when exposed to the fire: the castings would crack, none of the joints proved reliable, and those of the small steam pipes were especially troublesome, and another departure was made after three or four years' experience without much serious disaster. The second style of boiler, (which the prestige of advertising brought into immediate and extensive use in England), consisted of a nest of wrought iron tubes, slightly inclined from the horizontal line, of large diameter (8 to 10 in.) and 12 ft. or so in length; the ends of these tubes were joined into "fittings" of cast iron, and the "fittings" were held together by through bolts of sufficient strength. The details of this construction it is not necessary to describe, but only to say that the completed "safety boiler" was a number of rigid vertical grids of five pipes each, the number of grids employed giving the width of the boiler; and the separate sections were joined together by a cross bed pipe at one of the bottom corners, (the front and lowest one), and by small steam pipe necks to a steam main at one of the top corners (the back and highest one). This last construction obviated some of the constant leakages and other troubles of the former one, and removed the objection of a cast iron bed pipe, exposed to the fire; but while both kinds were deficient in circulating provisions for the heated water and insufficient in evaporating surface, the latter was radically and dangerously so; besides, from the grid shape of the sections, and the effect of unequal expansion, (when the bottom tube become overheated, by the failure of the circulation, and the water lifted from it), was to cause, or at least risk, the fracture of the fittings or of the tubes themselves. The liability to these accidents was of course diminished to some extent by the use of large tubes in the Howard safety boiler, but on the other hand the disastrous effect was increased by their unyielding, unelastic character when the bottom tubes should chance to empty.

The water hammer which follows the emptying (by the expansive force of steam formed next the fire surface) when the expanded superheated steam is absorbed into the returning columns of water, is

productive of shocks, which cannot be appreciated by any one who has not witnessed the behavior of an active hot water apparatus when its circulation from leakage or removal of water is broken in the continuity of the flow of its upper pipe. The convulsive discharges of water, the shock of contact of one mass of water with another, (in the bed pipe where no air is interposed), the violence of the actions and reactions, are something frightful to observe; and when one considers the quiet regularity of the circulation a few moments previously, although the furnace may have been consuming at the rate of 10 or 12 lbs. of coal per square foot of grate per hour, and its vehement, almost explosive condition following the failure to circulate, and applies the phenomena to the transmission of heat by a current of water from the fire surface of the bottom of a boiler to the water surface at the top (in place of from a fire surface to another surface), he will then discern the conditions of boiler circulation. These considerations would give a possible, if not probable, cause for the explosion which occasioned the inquest. The defect of iron which appeared, and was assigned by the defence as a reason, may have had a part in the accident, but it is questionable whether the blistered iron was an original defect or merely a result from overheat. From an experience in numerous come-downs in sheets over the fire, where the presence of tubes or of a flue above them, had prevented the adequate supply of "return" water, the writer feels confident in asserting that the apparent blisters, in many cases at least, are merely a development of the internal condition of the iron. Boiler plates are tested for strength in two directions. Plates rolled from homogeneous slabs or cross piles, or cross piled billets, will exhibit from 10 to 15 per cent. greater strength in the direction of the rolling or principal extension in forming the plates. But tests of strength in the direction of the thickness of the plates have never yet been made, and it is at once admitted that the lamilar action of rolling must stratify the sheet and affect the cohesion of the strata very materially. The tendency of a plate to laminate (not necessarily to blister) under the influence of excessive heat on the outside, with repeated reductions of temperature on the inside, is certainly a very great one. * * * *

There are boilers in which the main circulation takes place in the bed of nearly solid water, (underlying the layer of foam, or of mingled water and steam bubbles); the development of steam bubbles commencing at that elevation where the pressure of water column relieves the

heated water. The common upright tubular boiler is a case in point and there are in use one or more boilers of the tubulous character with horizontal tubes in which the separated circulation subsists. The original "Howard safety" depended on a similar circulation in its large upright tubes; but the second type, with its inclined (nearly horizontal) tubes appear to have had particular arrangement to prevent quiet circulation—it was *intended* that the steam-evolving water, after giving out its heat and steam, should lift high enough to overrun a bridge before it was to be allowed to return. * * *

This line of reasoning could be pursued further, with, perhaps, advantage to some readers, but it clearly belongs to other pages of the JOURNAL, and it is only needful to assert now, that there are numbers of men in England and in this country, engineers or professors, who have been, and are, well enough acquainted with the practical construction of boilers, (circulating or otherwise), the phenomena of ebullition and the laws of heat, to have expressed opinions as decidedly three years ago as they can now, after numerous disasters have happened. It was perfectly well known that the things were as complete traps, as any figure of four that was ever set. It was a mere question of time when a little extra firing, or an unusual demand for steam supply should overcome the columns of water, and that, in perhaps one case out of ten in such casualties, a catastrophe would ensue.

This Howard safety boiler is not the only one of the group which has needed criticism, supervision or restriction from use. Within three years, a safety boiler, yet more liable to accident and more dangerous when it occurred, has exploded in this city on its first trial, and the disaster was also attended by loss of life as well as property. And our City Boiler Inspector reports to Councils that there are other boilers of similar "safety" character, in use in Philadelphia.

It must not be supposed that these objections attach to all boilers, or to all tubulous boilers, or to all new kinds of boilers. There is a possibility of attaining a measure of safety from disastrous explosions in the construction of boilers in small and multiplied parts. These boilers cannot be said, generally, to offer any especial protection to attendants or firemen, (in truth some of them have been criminally dangerous in this regard), but they do present an immunity to the public, and to the owner, from extensive damage following an accident. The nearly insuperable troubles of construction, the diffi-

culties of cleaning, and the consequent rapid deterioration of these boilers as a rule, has kept them steadily in discredit, and of the number which have been introduced within twenty years, few, if any, exist to-day of three years' existence in unmodified forms; while inventors (with and without knowledge or prudence), are daily adding to our patent office records, and occasionally adding also to the disaster column of the newspapers.

Admitting this premise, the question which the boiler user, or the citizen whose property or life is endangered, naturally asks, is—Why is not the public attention called to these dangerous boilers? Simply because it is not only nobody's business to do it, but because it is the business of many people not to do it. Or replying by another question: What right has any person to express uncalled for, derogatory opinions to the great damage or loss of an inventor? especially when such opinions may be erroneous.

The laws of trade in steam boilers, do not differ from others—*Caveat emptor*, buyer beware. The advertisement is paid for, and it is to be hoped that it is all true, even to the word "safety," (which *may* imply a safety to those who let the boiler alone). The *purchaser* is fully instructed by the salesman or agent in the laws of heat, and their application to the particular safety devices, until his own reason is satisfied to the utmost. Under these circumstances, an explosion afterwards, or even a failure is borne with equanimity, and the result becomes one of those profitable investments in mechanical knowledge known as experience. Seriously, the only relief from these accidents to be looked for, is when the public shall put more reliance in sound professional advice, (not circulars), and less upon the advertisements of interested projectors or salesmen.

This conclusion is admitted to be somewhat inconsequent so far as protection of the citizen or employee is concerned, but the question of the compatability of a public censorship with the rights of inventors and the progress of mechanism—of mechanical predestination and free-will—is too broad to be discussed at this time; and having presented to our readers some of the aspects of the safety boiler question, its further consideration may be deferred until called for by the expression of public opinion in other prints.

Note.—The Tables referred to in article on "Trials of Steam Machinery," will appear with March number of JOURNAL, as a supplement.

Franklin Institute.

HALL OF THE INSTITUTE, Jan. 19, 1876.

The stated meeting was called to order at 8 o'clock, P.M., the President, Dr. R. E. Rogers, in the chair.

There were present 146 members and 11 visitors.

The minutes of the last stated meeting were read and approved.

The Actuary presented the minutes of the Board of Managers, and reported that at the last meeting the following donations were made to the library:

Second Geological Survey of Pennsylvania, 1874. Preliminary report of the mineralogy of Penna., by F. A. Genth, with an appendix on the hydrocarbon compounds, by S. P. Sadtler. Harrisburg, 1875. From G. W. Hall. 2d copy from A. K. Dunkel.

Special Report on the Petroleum of Pennsylvania. Its production, transportation, manufacture and statistics, by H. E. Wrigley, with maps and illustrations. To which are added a map and profile of a line of levels through Butler, Armstrong and Clarion Counties, by D. J. Lucas. Also a map and profile of a line of levels along Slippery Rock Creek, by J. P. Lesley. Harrisburg, 1875. From G. W. Hall.

Annual Report to the Stockholders of the Pennsylvania Steel Company, with plates and supplement. From the Company.

Annual Report upon the Improvement of Rivers and Harbors in New Jersey, Pennsylvania and Delaware, in charge of J. D. Kurtz, being Appendix X of the Annual Report of the Chief of Engineers for 1875. Washington, 1875. From J. D. Kurtz, Lieut. Col. Eng.

Second Geological Survey of Pennsylvania, 1874. Special report on petroleum of Penna., etc., by J. P. Lesley. Harrisburg, 1875. From A. K. Dunkel.

The Vienna Exposition. Report of the Philada. Commission to Vienna, J. E. Mitchell, President. From the Commission. Philadelphia, 1875.

Rules and Decisions of the General Assembly of Penna., etc., etc., by J. A. Smull. Harrisburg, 1875.

Auditor General's Report on Railroads, Canals and Telegraphs, 1873. Harribusrg, 1874.

Reports of the Inspectors of Mines of the Anthracite Coal Regions of Penna. for the year 1874. Harrisburg, 1857.

Commonwealth of Penna. Second Annual Report of the Bureau of Statistics of Penna. for the years 1873–74. Harrisburg, 1875.

Report of the Commissioners appointed to investigate the Bituminous Coal Mines of Pennsylvania. Harrisburg, 1875.

Commonwealth of Penna. Second Annual Report of the Bureau of Statistics of Penna. for the years 1873–74. Part II, Labor Report. Harrisburg, 1875. From G. W. Hall.

Revised List of the Vertebrated Animals now or lately living in the Gardens of the Zoological Society of London. Supplement containing additions received in 1872, '73 and '74. Also Parts 2 and 3 of proceedings. From the Society.

Miltheilungen der K. K. Geographischen Gesselschaft in Wien, 1874, Vol. 17. From the Society.

Fifty-fifth Annual Repart of the Managers of the Apprentices, Library Company of Philada, 1875. From the Library Company.

Second Geological Survey of Pennsylvania, 1874. Report of Progress in the Venango County district, by John F. Carl. Observations on the Geology around Warren, by F. A. Randall. Note on the comparative Geology of Northeastern Ohio, and Northwestern Pennsylvania, and Western New York, by J. B. Lesley. Harrisburg, 1875.

Report of Progress on the Brown Hematite Ore Ranges of Lehigh County, with a description of the mines lying between Emans, Alburtis, and Fogelsville, by Fred'k Prime, Jr. Harrisburg, 1875.

Second Geological Survey of Penna., 1874–5. Report of progress in the laboratory of the survey at Harrisburg, by Andrew S. McCreath. Harrisburg, 1875. From the Board of Commissioners.

Eighty back numbers of the JOURNAL OF THE FRANKLIN INSTITUTE. From J. T. James, 1023 Arch St., Philada.

The Elements of Graphical Statics and their applications to framed structures, with numerous practical examples of cranes, bridge, roof and suspension trusses, braced and stone arches, pivot and draw spans, continuous girders, etc., 2 vols. Text and plates by A. Jay Du Bois, C.E. From John Wiley & Son, Publishers, New York.

Minutes of Proceedings of the Institution of Civil Engineers, with other selected and abstracted papers. Vol. 42, Session 1874–5, Part 4. London, 1875. From the Society.

Circular of Information of the Bureau of Education, No. 7. 1875. Constitutional provisions in regard to education in the several states of the American Union. Washington, 1875. From the Bureau of Education, Washington, D. C.

British Patent office publications for the weeks ending February 27th and March 6th; also from March 20th to November 12th, 1875, inclusive. From the Commissioner of Patents, England.

Commonwealth of Pennsylvania. Official Legislative Directory, Session of 1876. Harrisburg, 1875.

Annual Report of the Secretary of Internal Affairs of the Commonwealth of Pennsylvania, for the year ending Nov. 30th, 1875. Part I. Land Office, Harrisburg, 1875.

Annual Report of the Superintendent of the Soldiers' Orphans of Pennsylvania, for the year 1875. Harrisburg, 1875.

Common Schools of Pennsylvania. Report of the Superintendent of Public Instruction of the Commonwealth of Pennsylvania for the year ending June 1st, 1875. Harrisburg, 1875. From Geo. W. Hall.

Department of the Interior; U. S. National Museum No. 1; Bulletin of the U. S. National Museum, No. 1; Check List of the North American Batracha and Reptilia, by E. D. Cope. Washington, 1875.

Department of the Interior, U. S. National Museum No. 2; Bulletin of the U. S. National Museum, No. 2; Contributions to the Natural History of Kerguelen Island, by J. H. Kidder, M.D. Washington, 1875.

Smithsonian Miscellaneous Collections, 238. List of the institutions, libraries, colleges and other establishments in the United States in correspondence with the Smithsonian Institution. Washington, 1872.

Smithsonian Miscellaneous Collections, 243. List of foreign correspondence of the Smithsonian Institution. Corrected to January 1872. 4th edition. Washington, 1872. From the Smithsonian Institution, Washington, D. C.

Circulars of Information of the Bureau of Education, No. 8, 1875. Schedule for the preparation of students' work for the Centennial Exhibition, etc. Washington, 1875.

The Actuary also reported the following action: The award of the Scott Legacy Medal and Premium to C. Tyson for his machine for uniting the soles to boots and shoes, and the Elliott Cresson Gold Medal to Dr. W. G. A. Bonwill for his electro-magnetic mallet for dental purposes, and recommending that the use of the Lecture Room on June 13, 14, and 15, next, be tendered to the American Society of Civil Engineers for the purpose of holding its annual convention.

The President presented the annual report of the Board of Managers, as follows, which was adopted:

Report of the Board of Managers to the Franklin Institute of the State of Pennsylvania.

Your Board of Managers beg to present the following report:

During the year 1875 there have been added to the list of members one hundred and forty, and removed from it by resignation, twenty-four, leaving an increase to the entire number of one hundred and sixteen.

The Report of the Treasurer herewith submitted as a part of the minutes of the Board, furnishes the following exhibit:

Balance on hand Jan. 1st, 1875, .	$61,336·09
Receipts during the year, . . .	27,907·95
Total, ...	$89,244·04
Expenditures and investm'ts during the year,	87,025·39
Leaving a balance on hand Jan. 1, 1876,	$2,218·65

The Journal of the Institute, which is under the management of the Editor and the Committee on Publication, has been for the year nearly self-sustaining. Including the amount previously on hand, there is a balance to its credit.

During the year the following medals have been awarded:

Elliott Cresson Gold Medal.

To Joseph Zentmayer, of Philadelphia, for improvements in Microscopic Objectives.

To Chambers Brothers, of Philadelphia, for improvements in Book Folding and Pasting Machines.

To Powers & Weightman, of Philadelphia, for the production of Citric Acid and the cheaper alkaloids of Cinchona Bark.

To Bullock Printing Press Co., of Philadelphia, for Bullock Printing Press.

Scott Legacy Premiums and Medals.

To John G. Baker, of Philadelphia, for Rotary Pressure Blower.

To Hutchins & Mabbitt, of Philadelphia, for Tilting Chair.

To J. Morton Poole & Co., of Wilmington, Del., for improvements in Grinding Calender Rolls.

To T. J. Rorer, of Philadelphia, for Union Belting.

To E. A. Goodes, of Philadelphia, for Sewing Machine.

To John E. Prunty, of Wilmington, Del., for Automatic Relief Valve for Steam Fire Engines.

To Geo. Wale & Co., of Hoboken, N. J., for College Lantern.

To H. R. Heyl, of Philadelphia, for wire fastened Paper Boxes.

To Wilcox & Gibbs Sewing Machine Co., of New York City, for Automatic Tension and other improvements in the Wilcox & Gibbs Sewing Machine.

To R. B. Goodyear, of Philadelphia, for Box Motion for Looms.

To Job A. Davis, for Vertical Feed, applied to Davis' Sewing Machine.

To Sholes & Glidden, of Philadelphia, for Type Writer.

To B. Tatham and J. W. Brittin, of New York, for Safety Catch for Elevators.

Drawing School.

It is with much satisfaction that the Board are able to report the steady growth of the night drawing school, under the auspices of the Institute.

During the Spring term there were in attendance eighty-one pupils, and during the Fall term, one hundred and fifty-three, being in the aggregate a large increase over previous years, a fact which furnishes evidence of the good work the Institute is accomplishing in promoting one of the best ends of its organization.

Lectures.

Courses of interesting and instructive lectures have been given during the interval between the beginning of November and the end of December of the year, on the following subjects:

On Acoustics, by Prof. E. J. Houston; on Mathematics, by Prof. D. D. Willard; on Gas Lighting, by Prof. W. H. Wahl; on Mineralogy, by Mr. T. D. Rand; and a special one for "young people," on "Experimental Science," by Prof. Houston.

Monthly Meetings of the Institute.

The attendance at the monthly meetings of members and strangers has much increased during the year, and interesting communications and noteworthy inventions and novelties have been presented and discussed on those occasions.

Alterations of the Hall.

Since the last Annual Report of the Board of Managers, the committee which had been authorized to act in the premises, have caused to be made several useful changes in the Institute Hall.

These changes have consisted in removing one of the common stairways; in enlarging the library room, and adding offices on that floor, in considerably increasing the capacity of the drawing school rooms; and in introducing a better system of heating and ventilation of the building.

Library.

With a better condition of the finances, resulting from the success of the exhibition, held between October 6th and November 12th, 1874, the Library Committee have been enabled, under authority given it, to improve considerably this valuable feature of the Institute,

by the purchase of new books, and binding and giving shelf room to many volumes hitherto almost inaccessible.

It is believed that the members generally, and certainly the public at large, are not aware of the treasure of practical knowledge contained in this collection, which has had its growth through the period of a full half century.

Besides whole series of most of the scientific periodicals of the day, it contains volumes upon nearly every practical and manufacturing art, and is at once a source for reference, invaluable to the scientific investigator, the inventor and the artisan, each seeking information in the line of his pursuit.

A statement of the condition of the library will be presented by the Committee on the Library.

The report of the Committee on Models will be read at this meeting, and will show what has been done in that connection.

In view of the facts herein set forth, the Board of Managers feel that they can cordially congratulate the Institute upon its increased prosperity and its promising prospects in the future.

All of which is respectfully submitted.

By order of the Board.

R. E. Rogers, *President.*

The Committee on Library presented the following report, which, on motion of Mr. Sellers, was adopted, and the Secretary was directed to convey to Mr. Ransom the thanks of the Institute, as therein recommended:

The Committee on Library respectfully report that regular meetings have been held during the year, which have been well attended.

An appropriation of $5000 was made by the Board of Managers, on January 15th, for the purchase of books; and the work of making selection at once began; but, in the absence of a correct catalogue, it was found difficult to make the proper selection, and consequently only $1394.41 of this amount has been thus far expended. The purchases made were carefully selected, and a large number of very valuable works have been added to our collection. The necessity of a new catalogue of the library has long been felt, and its preparation has only been postponed for want of funds, but that difficulty being overcome, its preparation was begun in earnest, and Mr. Geo. Corliss, a gentleman of considerable experience in such matters, was engaged for the work, and the catalogue is now ready for the printer.

The labor involved was greatly increased by the necessity of rearranging the books on the shelves, which arose from the fact that

the classification of the books on the shelves had become very imperfect from the large increase of the number of volumes since the original arrangement. The rearrangement of the books has been carefully done, not only with the view to the classification of subjects, but also to the probable increase for some years.

During the past summer the library room has been enlarged by the removal of the south staircase and a portion of the partition, so as to throw about three-fifths of the entry into the library room, and bringing it in direct communication with the two front rooms on the same floor; one of these rooms, and also the room formerly occupied by the Actuary, were appropriated to the use of the library.

The book cases were increased about fifty per cent., the whole room painted, and lighted with a row of chandeliers along the centre, and the floor covered with matting.

At the beginning of the year there was on hand a balance of $562.07 of the fund bequeathed to the Institute by Mr. A. S. Roberts, for the purchase of books, which has all been expended, and the books properly labeled.

A strong effort has been made to complete the set of British Patent Specifications and with such good results that there are now comparatively few missing ones. In this effort the committee have been greatly aided by Mr. Fred'k Ransom, of London, Eng., who visited the Patent Office, and otherwise used his personal influence in our behalf, and to him the committee consider the thanks of the Institute are due.

There was on hand January 1st a fund of $455, raised by subscription some time ago for binding British patents, and with this they have been bound as far as the series was sufficiently complete, leaving a balance still on hand of $186.

The following additions to the library were made during the year:

Donations of Bound Volumes, . . .		44
Number of Volumes purchased, . . .		272
No. of Volumes of Exchanges bound, . .		356
No. of Volumes added to the catalogue which were previously in the library, ...		236
Volumes of British Patent specifications bound,		650
78 abridgments of British Patent specifications bound in volumes, ...		49
Total No. of bound Vols. added to catalogue,		1607
Donations of pamphlets, ...	158	
Volumes rebound, ...	126	

The use of the library by members has been much greater since the improvements, and cannot fail to be still farther increased upon the completion of the catalogue.

CHAS. BULLOCK, *Chm. Com. on Library.*

The Committee on Models presented their report, as follows, which, on motion, was adopted:

The Committee on Models respectfully report that there have been held during the year one special and six stated meetings, which, however, were not very fully attended.

The necessity for more room for the drawing school made it desirable to remove the partition between the model and school rooms and the middle row of tables, the models being distributed in other portions of the room, and thus adding a considerable space to the school room.

At the beginning of the year the model room was in a very disordered condition, large quantities of *debris* of exhibition, and refuse material used about the Institute being stored in it. The models were much scattered and a large number of them in pieces.

The members of the committee found it impossible to give their personal attention to the work of clearing out the foreign matter and arranging the models, and therefore at the stated meeting, in March, a resolution was adopted asking the Board of Managers to appropriate $100 to be expended in this work. This appropriation was made (as also a subsequent one of a like amount), and an engagement was made with Mr. L. L. Cheney, who, under the direction of the Secretary and the committee, selected out and removed the useless material, assembled together the parts of models as far as possible, and made some progress in arranging them.

Although the collection of models is not large, there are quite a number that are of great historical value, but it is to be greatly regretted that the book in which they are registered is lost. It is proposed to make a new register and to collect such information regarding them as can be obtained, and to this end the committee recommend that all members of the Institute be requested to send to the Secretary such facts as they may be in possession of, regarding them. This work was suspended because of the alterations and repairs to the building, and has not since been resumed because of the pressure of other work on the officers and employees of the Institute, but the committee recommend that it be continued to completion.

C. Cabot, *Chm. Com. on Models.*

Dr. H. W. Adams read a paper on the use of steam in burning bricks.

The Secretary's report embraced Edson's Time and Pressure Recording Gauge; Buzby's high pressure dissolver for Oxy-Hydrogen Lantern; Colburn's Porous Evaporator; Shinn's Rail Joint; Simpson's Combination Lock, Lever and Strap for Trunks; and Tingley's Steam Canal Boat.

Under the head of deferred business, the subject of the election of a trustee to the Pennsylvania Museum and School of Industrial Art was taken up, and Mr. Coleman Sellers nominated Mr. J. B. Knight; and no other nomination being made, on motion, Mr. Knight was declared elected.

The tellers of the annual election held this day presented their report, which, on motion of Mr. Mitchell, was accepted and the President declared the following members elected:

President, Robt. E. Rogers, M.D.
Vice-President, J. E. Mitchell.
Secretary, J. B. Knight.
Treasurer, Fred'k Fraley.
Managers to serve three years, Wm. Sellers, Hector Orr, J. Vaughan Merrick, Henry Cartright, Cyrus Chambers, Jr., H. W. Bartol, Jas. Hunter.
Auditor, Samuel Mason.

The eighth highest number of votes for managers having been cast for two persons, it was decided to be a tie and only seven members of the Board were declared elected.

Mr. J. E. Mitchell offered the following, which was adopted:

As one by one our of members fall from our ranks, it becomes our duty that some record should be made of our appreciation of their usefulness as members of this Institute, and of our respect for their memory as honored and public spirited citizens.

On the 21st of December, 1843, Mr. Geo. Hall became a life member of the Franklin Institute. As early as the year 1830, he was extensively engaged in the manufacture of silverware, as a member of the firm of Boardman & Hall. In 1833, he was called to occupy one of the most responsible positions in the coinage department of the United States Mint, which, by his strict integrity of character and close attention to his duties, enabled him to hold through the various changes in the administration of the mint until the year 1863, when the infirmities of advancing years compelled him to resign.

Mr. Hall died on the first of October last, in the 78th year of his age, respected and mourned by a large circle of friends; therefore,

Resolved, That the Secretary is hereby directed to place on record this testimonial of our respect for the memory of our departed member, and that a copy of the same be sent to his family.

Mr. Hector Orr presented the following preamble and resolution, which, on motion, were adopted.

WHEREAS, A Centennial Celebration characterized by an exhibition of industrial products, originally suggested by this Institute, bids fair to become one of the leading accomplishments of the age—and

whereas its international features have been established by a hearty recognition of our appeal by most of the nations of the world; therefore,

Resolved, That we respectfully ask the national government to authorize forthwith an appropriation of money sufficient to complete this great work.

On motion, the meeting then adjourned.

J. B. KNIGHT, *Secretary.*

Centennial Supplements to the Journal.—It is proposed to publish from time to time, as material of suitable character may be presented, a series of supplements to the JOURNAL, which shall contain articles describing machinery, apparatus or other subjects of interest to science or the arts. These supplements will have the book form of the JOURNAL so as to become a part of the library collection for future reference. They will be furnished to the regular subscribers for the present year without charge. It cannot now be stated to what extent this means of circulating unprejudiced and impartial description of novelties or standard works may be availed of by the exhibitors, but it may be reasonably anticipated that many of them will regard the proposition of the committee on publication and the editor with favor, and that both the readers of the JOURNAL, and the cause of scientific information receive advantage from the supplement. For further information on this subject, we refer to the Prospectus in the advertising form of this number.

The Manufacture of Tubes of Large Size.—The National Iron Tube Company, whose works are situated at McKeesport, in this state, have recently made welded wrought iron tubes so large as 15 inches in diameter. For the boilers of Western river steamboats, the substitution of welded for riveted flues will be a great gain in strength and consequent safety, while the reduction of weight from avoidance of laps and rivets enables this improvement to be effected without addition to the total cost. The eventual substitution of wrought for cast iron pipes and of welded tubes for riveted ones seems to be merely a question of a supply at moderate prices, to result from the improvement of machinery and furnaces.

Note.—The two articles which will be found on other pages of this number of the JOURNAL, on "Ring Spinning" (F. H. Silsbee) and on "The Use of the Microscope in Analysis" (Frank W. Very) are theses of the advanced students of the Massachusetts School of Technology.

Bibliographical Notice.

REPORT ON BUILDING STONES.—By Maj. Gen. Q. A. Gilmore, Lieut. Col. Corps of Engineers U. S. A. 42 pp. D. Van Nostrand, New York. Reprint abstract from official report to the Chief of Engineers.

This is one of a series of publications of Gen. Gilmore upon materials used in construction, all of which are of extreme value as books of original information, collected into forms suitable for use and reference by the practical engineer. A discussion on the theory of elasticity of solid bodies, as applied to building stones is perhaps not so complete from a mathematical point of view as could be wished by the student, but it is ample for the purpose of argument in disabusing the constructing engineer or workman of idea that material under compression is only under stress in the line of the axis of compressive force, and the writer takes decided exception to the words. "It need hardly be said to engineers that such strains have existence only in the pages of mathematical applications," for it is in those pages that the contrary assertion is especially laid down. The examples taken of granite, marble, sandstone, are available for American practice, and will be taken as authoritative in the construction of piers or foundation walls hereafter. Some remarks are made as to the effect of interposition of material of lower or high elasticity of form upon the surface of the cubes of stone which were tested to fracture, but the mathematical propositions involved are not considered, nor are the effects upon ultimate strengths fully elucidated. No notice is taken of the impairment of strength by compression between surfaces of *less* size than those of the body under test, nor does the investigation embrace suddenly applied loads or attempt to measure the effects of blows either of falling or moving bodies. A modulus of elasticity of these stones, and their expansion, conductivity and other effects of heat, would be an excellent addition to the knowledge of the engineer. The publication of such memoirs in separate book form is a great convenience for the library, and this work is worthy to be one of an engineer's collection.

We wish to call attention to another publication of Van Nostrand, the "*Eclectic Engineering Magazine*," with an especial reference to a valuable article on the steam space in passages of the Woolf engine, translated from the *Bulletin de la Soc. Industriel de Mulhouse*—O. Holauer, which appears in the January and February numbers. This article had been selected for translation for the JOURNAL OF THE FRANKLIN INSTITUTE, but its prior appearance in a magazine so well known to our readers, renders another publication unnecessary.

Civil and Mechanical Engineering.

COTTON MANUFACTURE AND THE RING FRAME.

By F. H. Silsbee.

It may not be out of place to make a hasty review of the progress which has been made in the manufacture of cotton, and of the processes through which it has to pass, to transform the crude fiber into the finished cloth, before taking up the more immediate subject of this paper.

Cotton is the downy fibrous substance attached to the seeds of the various species of Gossypium, (a genus of plants of the order Malvaceæ), of which there are three principal varieties, namely: the herbaceous, the shrub, and the tree cotton, and of these the herbaceous is the most important. Some include in it all the varieties cultivated in the United States, but others refer the long-stapled sea-island cotton-plant to the arborescent division. The cotton raised in the United States, however, is usually considered to consist of two varieties, namely: the "sea-island," or "black seed cotton," which is long-stapled, and the "upland," or "green seed cotton," which is short-stapled.

The largest proportion of the cotton manufactured comes from the southern part of the United States, although large quantities are raised in the East and West Indies, Surinam, and Egypt. The cultivation of cotton in the United States was not carried on to any great extent until towards the close of the last century. Mr. Timbs in his book on "Wonderful Inventions," has a paragraph which shows how important the exportation of cotton from this country to England was in 1784. In that year, he says: "An American vessel arrived at Liverpool, having on board eight bales of cotton, when they were seized by the custom-house officers of that port, under the impression that they had been imported from some

other country, as they had never before seen American cotton. In 1785 only five bags were imported, and next year six; such were the small beginnings of that immense trade, which now gives employment to millions on both sides of the Atlantic." The superiority of American cotton however, especially of the sea-island variety, soon caused a great demand for it, and in 1855, the total value of the American cotton crop was estimated at $140,000,000. This increase in the production of cotton was, besides its good qualities, in a great degree owing to the increased facilities for manufacturing it, and also for ginning it or separating the fiber from the seeds.

In a paper read by Mr. Atkinson, at the last meeting of the New England Cotton Manufacturers' Association, it is shown that the property which the cotton fibers have of holding together, when the yarn is spun, is not due to any scale or beard, as in the case of wool, but to the fact that the fibers have a natural twist in them, and therefore, when the cotton is pressed and twisted together, these twists are forced into each other, just as two spiral springs would be if pressed together.

The use of cotton for the manufacture of cloth was known to the inhabitants of India and Egypt over 3000 years ago, and mention is made of it by Heroditus about 450 B. C. Cotton was known in Spain in the twelfth century, and was eventually introduced into England; but, except for candle wicks, it was not much employed there before 1641, when it was used at Manchester in making fustians and dimities.

The great starting point of the cotton manufacture in England may be dated from the year 1760. In that year, the Society of Arts offered a premium for the greatest improvement in the common spinning wheel, and afterwards offered £100 for a machine that would spin six threads of wool, cotton, flax, or silk at the same time. In the year 1760, or soon after, Hargreaves, a Lancashire weaver, invented the carding machine, which was somewhat similar to that now used; and in 1767 he invented the spinning jenny, which at first contained eight spindles, but the number was afterwards increased to eighty. In 1769 the method of spinning by means of fluted rolls, through which the cotton is passed, in order to draw out the "roving" to the required thinness, was introduced by Arkwright, who first put it in a practical shape, although the invention is claimed for Paul and Wyatt. This machine was at first driven by water-

power, and hence was called the water frame. In 1779 Samuel Crompton invented the mule, which after several unsuccessful attempts, was made self-acting, about forty years ago. It was a vast improvement over any of the previous spinning machines, as it required less power and was capable of spinning much finer threads. About 1784 Cartwright invented a rude sort of power loom, which, like all the other inventions, has since been much improved. About this time also, the "dresser" was invented, by means of which the yarn is sized, in order to make it stronger for the operation of weaving. Since this time, very few radical changes have been made in the process of making cotton cloth, with the exception of the ring frame, which I shall mention farther on; although of course the machines have been so much improved as to appear almost like new inventions. It is curious to notice the increase in the number of factories, brought about by the improvements in the machinery. In 1780 there were only twenty cotton factories in England, and in 1790 there were one hundred and fifty. In a little book by Mr. Batchelder, entitled the "Introduction and Early Progress of the Cotton Manufacture in the United States," there is a great deal of interesting information, and many curious statistics given in regard to the early history of the cotton manufacture, both in this country and in England; but I have only room here to mention some of the most important and interesting points. The first factory for the manufacture of cotton, built in this country, was commenced at Beverly, Mass., in 1787. In Washington's diary, dated Friday, October 30th, 1789, is the following description of the Beverly factory: "After passing Beverly two miles, we came to a cotton manufactory, which seems to be carrying on with spirit, by the Cabots (principally). In this factory they have the new invented carding and spinning machines. One of the first supplies the work, and four of the latter; one of which spins eighty-four threads at a time, by one person. The cotton is prepared for these machines, by being first (lightly) drawn to a thread, on the common wheel. There is also another machine for doubling and twisting the threads for particular cloths; this also does many at a time. For winding the cotton from the spindles and preparing it for the warp, there is a reel, which expedites the work greatly. A number of looms (fifteen or sixteen) were at work, with spring shuttles, which do more than double work. In short, the whole seemed perfect, and the cotton stuffs which they turn out ex-

cellent of their kind—warp and filling both cotton." This factory was built of brick, and was continued in operation to some extent for several years, being driven by horse-power. After this, factories were built in other parts of Massachusetts, and also in Connecticut, Rhode Island, New Jersey, and several other states.

The following table taken from the report of Tench Coxe, of the census of 1810, shows the number of cotton factories in the different states at that time:

New Hampshire,	Twelve.	New Jersey,	Four.
Massachusetts,	Fifty-four.	Pennsylvania,	Sixty-four.
Vermont,	One.	Delaware,	Three.
Rhode Island,	Twenty-eight.	Maryland,	Eleven.
Connecticut,	Fourteen.	Ohio,	Two.
New York,	Twenty-six.	Kentucky,	Fifteen.
		Tennessee,	Four.

None in any other state.

But after the cotton manufacture was once started in this country, it progressed very rapidly, as is fully seen in the case of Massachusetts, upon examining the history of some of our most important manufacturing cities. The first mill was built at Fall River, in 1813, and in 1873, there were about thirty-three incorporated companies, owning 1,209,644 spindles. The Merrimac Mill, the first one built in Lowell, was erected in 1822. The Hamilton Mill was built in 1825, and afterwards the Appleton, Tremont and Suffolk, Boott, and several others were erected. In Lawrence, the increase in population, owing mainly to the rapid growth of cotton factories, was so great that it became a town in 1847, and in 1853, only six years afterwards, it became a city.

The number of spindles in New England in 1850 was estimated at 2,751,078; the population according to a census taken at that time being 2,728,106, which gives an average of 1008 spindles to 1000 inhabitants. Curiously enough, at this time in England, Scotland, and Wales, the number of spindles was 1003 for each 1000 inhabitants.

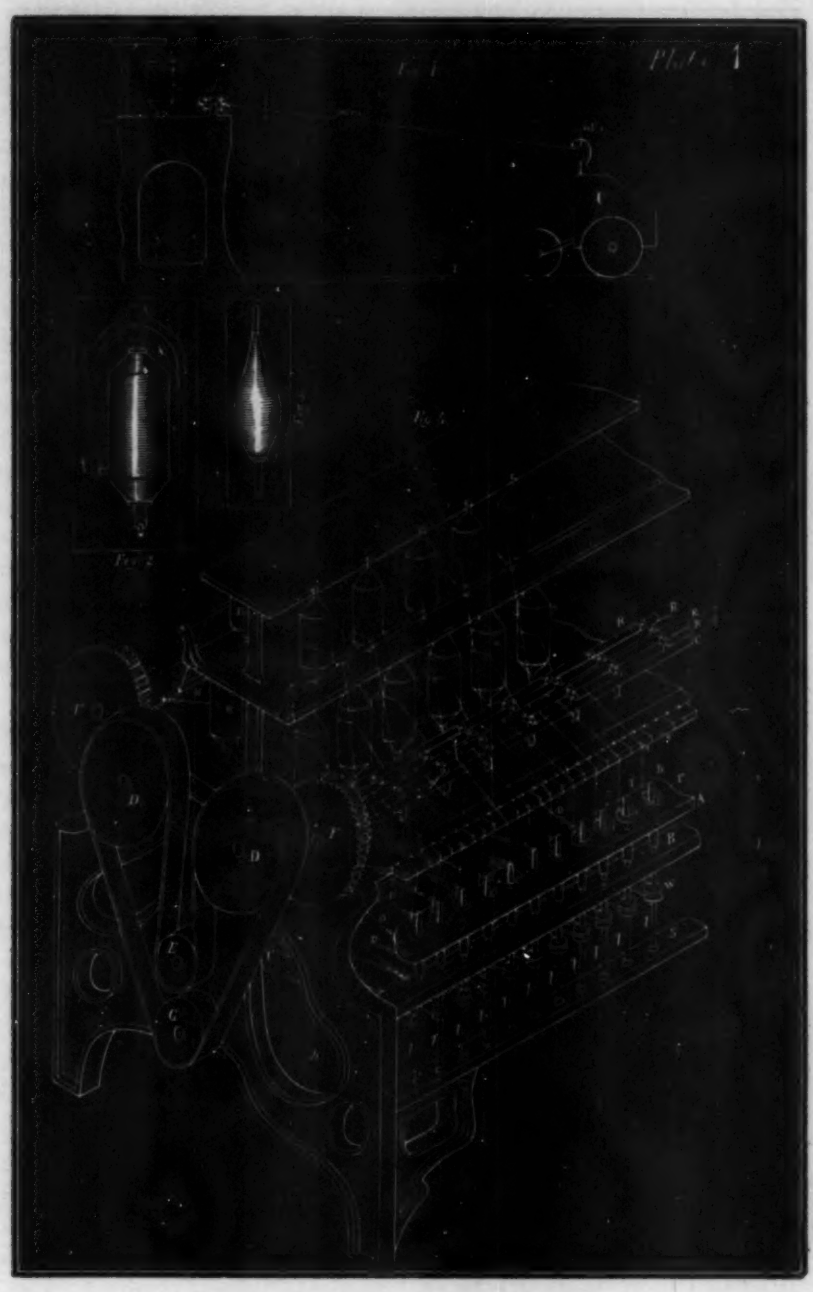
Having now given a hasty review of the early history and progress of the cotton manufacture, I will endeavor to give a general description of the various processes through which the cotton has to pass. I will begin with the cotton as it is brought to the factory in bales, having been previously ginned on the plantations where it was raised.

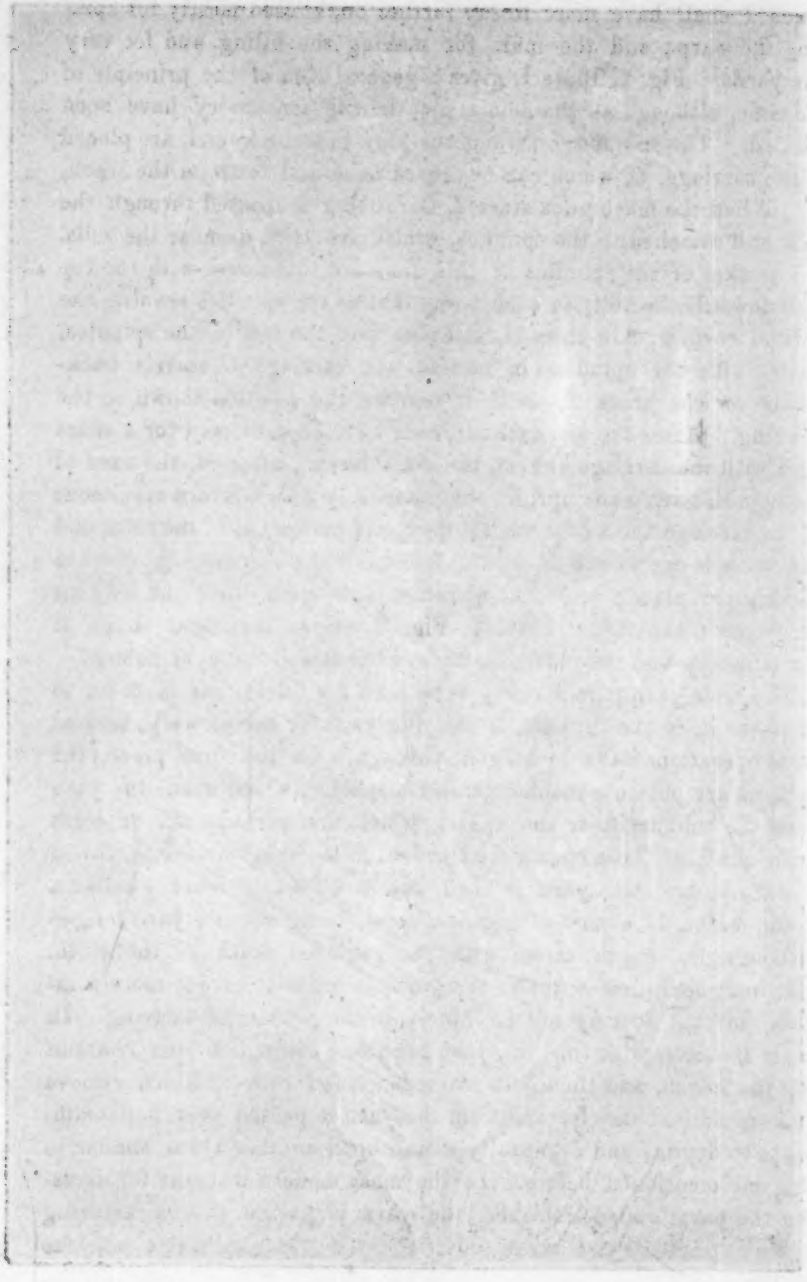
In order to make the cotton up into compact bales convenient for exportation, it is necessary to compress it in powerful presses, and this operation of course makes the cotton stick together in lumps, therefore the first process is to break up these lumps, so as to reduce the cotton to the same state that it was in, before being baled. In order to accomplish this, the bales are taken to the picker room, where they are broken open, and if various kinds of cotton are intended to be used together, they are mixed here. The cotton is then put into a machine called an opener or beater, where the lumps are in a great degree opened, and considerable of the dirt beaten out. As the cotton issues from this machine, it is spread out in a sheet, about two or three feet wide and one or two inches thick, and is rolled up on a wooden bar. Two or three of these rolls are then passed through another machine called a picker or lapping machine, which is furnished with blunt revolving knives, which tear the fibers apart, and thus complete the operation of opening the cotton. The cotton also comes from this machine in the shape of a roll, called a "lap," the weight of which varies with the size of the yarn which it is desired to make. Having now opened the cotton, the next operation is to straighten the fibers and make them parallel. In order to do this the "lap" is placed on a carding machine, which, in the form most commonly used in this country, consists of a large cylinder covered with leather, in which are set short, bent, sharp-pointed wires. Over the top of this cylinder are flat strips of wood, also covered with wire. In front of this large revolving cylinder is a smaller one, called a "doffer," turning in an opposite direction. The cotton is drawn through between the cylinder and the flat strips, and then passes on to the "doffer," from which it is removed by means of a fine comb, which takes off the cotton in a delicate lace-like sheet, but it is immediately passed through a trumpet-shaped opening, which condenses it into a narrow band called a "sliver." The "slivers" from five or six cards are then passed through what is called a railway head, which consists essentially of three sets of rolls, of two in each set, placed above one another. The back set, which receives the cotton, revolves a good deal slower than the front one, which delivers it, and thus the separate "slivers" are joined together and drawn out, which operation tends to straighten the fibers. As it is necessary that the weight of the sliver as it comes from the railway head, should be as uniform as possible, there is a regulator attached,

through which the sliver passes and the friction of the cotton causes the regulator to move forward or back, as the weight of the cotton becomes greater or less, and this movement of the regulator determines the relative speed of the rolls. From the railway head, the "sliver" is passed through two drawing frames, which are essentially the same as the railway head, except in a few matters of detail.

In both of these drawing frames, several "slivers" are passed in together and drawn out as one, the object of this "doubling" being that the inequality of one "sliver" may neutralize that of another. After the drawing on the drawing frames is completed, the "sliver" is too weak and small to stand any more drawing, and yet it is still too large for the desired yarn, and the fibers are not yet sufficiently straightened; it is therefore necessary to twist it slightly in order that it may bear more drawing. For this purpose it is passed through three machines, called respectively the coarse speeder or slubber, intermediate, and fine speeder or fly frame. These are almost precisely alike, and therefore a description of one will do for all. The sliver, which is brought from the machine last described coiled up in cans, is first passed through rolls, similar to those of the drawing frame, which are placed on the upper part of the frame, and from these rolls it passes down through what is called a flyer, *f*, (see Plate I, Fig. 2), and is then wound upon the bobbin, *s*. The drawn sliver enters through a hole in the top of the flyer centrally, passes over or along the bow to one leg, and down the leg to the point *f*, where it emerges and is led over to the bobbin. Both the flyer and bobbin rotate rapidly, and it is evident that the motion of the former causes a twist to be put into the sliver, or "roving," as it is now called. Now, if the roving passes through the flyer and is attached to the bobbin, and the latter moves faster than the former, it is evident that the yarn will be wound on the bobbin. As far as the winding on is concerned, it makes no difference which moves the faster; but some manufacturers prefer to have it one way, some another. The roving, having now passed through the three fly frames, is ready for the spinning machine.

Of spinning machines there are three kinds, *i.e.*, the throstle, ring frame, and mule. Of these, the former has almost wholly gone out of use in this country, having been superseded by the ring frame, although it is still used quite extensively in England. The ring frame, of





which I shall have more to say further on, is used mostly for spinning the warp; and the mule for making the filling, and for very fine yarns. Fig. 1, Plate I, gives a general idea of the principle of the mule, although all the details and driving machinery have been omitted. The spindles, on which the yarn is to be wound, are placed in the carriage, *C*, which can be moved back and forth on the track, *T*. When the machine is started, the roving is passed through the rolls and attached to the spindles, which are then up near the rolls.

The axes of the spindles at this time are tilted over with the top ends towards the rolls, in such a way that as the spindles revolve, the twisted rovings, now threads, will pass over the end of the spindles, while, with the spindles in motion, the carriage *C* travels backwards on the track *T*, until it reaches the position shown on the drawing. After the elongated threads have been twisted for a short time with the carriage at rest, the rolls having stopped, the axes of the spindles are made upright simultaneously with a return movement of the carriage and a continued stoppage of movement of the rolls, and the threads are wound up on the bobbins when the carriage reaches its original place; and this operation is repeated until the bobbins or "cops" are full. Plate I, Fig. 3, shows the usual shape of the mule cop and the difference between that and the flyer bobbin.

The mule yarn is now ready to be used for filling, but in order to fit either it, or the throstle, or the ring yarn for use as warp, several more operations have to be gone through. In the first place, the bobbins are put on a machine called a spooler, which winds the yarn from the bobbins on to the spools, which are perhaps six or eight inches high. These spools are then set in a triangular frame, called a warper, and the yarn is then wound off on to what is called a beam, which is a sort of gigantic spool, being about a yard long—although its length varies with the required width of the cloth. The next operation is to size the yarn, in order to give it more firmness, so that it may not be injured in the process of weaving. In order to accomplish this, the yarn is passed through a tank containing the starch, and then between brushes and rollers, which remove the superfluous starch; and then the yarn is passed over hot steam-pipes to dry it; and eventually wound upon another beam, similar to the one mentioned before. In the most modern machine for dressing the yarn, called a slasher, the yarn is passed over a revolving cylinder heated by steam in order to dry it; and the whole machine

is more compact and does its work quicker than the old-fashioned dresser; for the finer yarns, however, such as Nos. 80 and 100, the old machine is found to do the best work. The ends of the warp are now passed through the eyes in the "heddles," or "harnesses," and the beam is then ready to be put on the loom.

The loom for ordinary weaving, has two harnesses which are moved alternately up and down. These harnesses, as they are called, each consist of two horizontal wooden bars placed directly above each other, and connected together by means of cords, having loops in the centre of each. In threading these harnesses, one thread is passed through the loop of one harness, one through that of the other, thus alternating with every other thread except on the edges, where two or three threads are passed through one loop, in order to form the selvedge. Now as these harnesses are moved up and down, an opening is left, through which the shuttle containing the bobbin of filling, is thrown by means of a sort of hammer, one of which is placed at each side of the machine, so as to drive the shuttle back and forth. Thus it is evident that the shuttle will go over every other thread, and on returning will go under the threads it went over before, thus forming good firm cloth. It is a somewhat curious fact, that although in order to have the drawing and spinning go on properly, it is necessary to have the air in the room quite dry, yet for good weaving, the air should be quite moist, and this is one of the reasons why it is advisable to have the looms on the lower floor. After the cloth has been woven, it is only necessary to examine it, to discover any imperfections, and it is then ready to be measured and cut to the proper length, and packed for exportation.

It must not be supposed from the hurried manner in which I have described the process of manufacture, and the various machines employed, that the operation is a very simple one, for on the contrary the whole process is one which requires a great deal of care, judgment, and experience, in order to be conducted successfully; and nearly all the machinery employed is quite complicated, some of it making use of a great variety of mechanical movements, which it would be impossible to describe here.

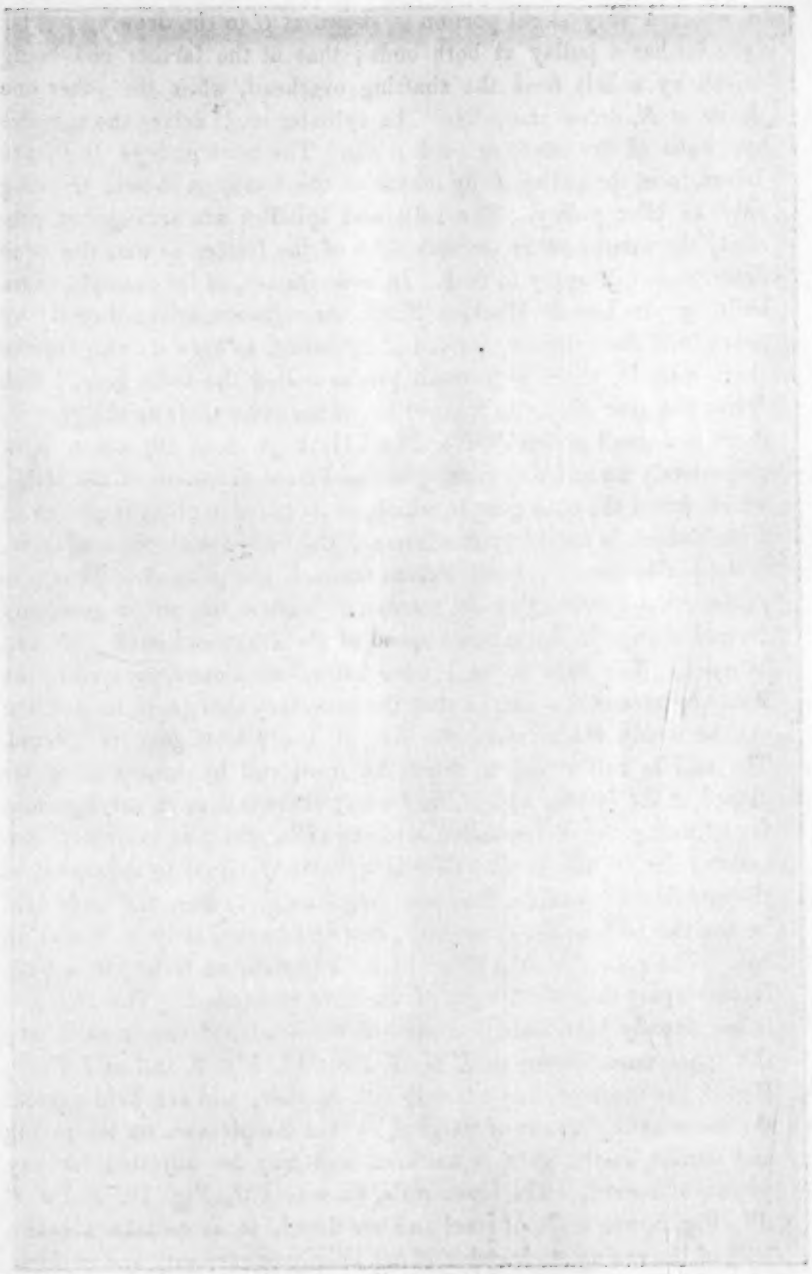
Having now briefly described the general process, I will take up more minutely the special method of ring spinning, and endeavor to point out some of its advantages and disadvantages, together with some of its peculiarities.

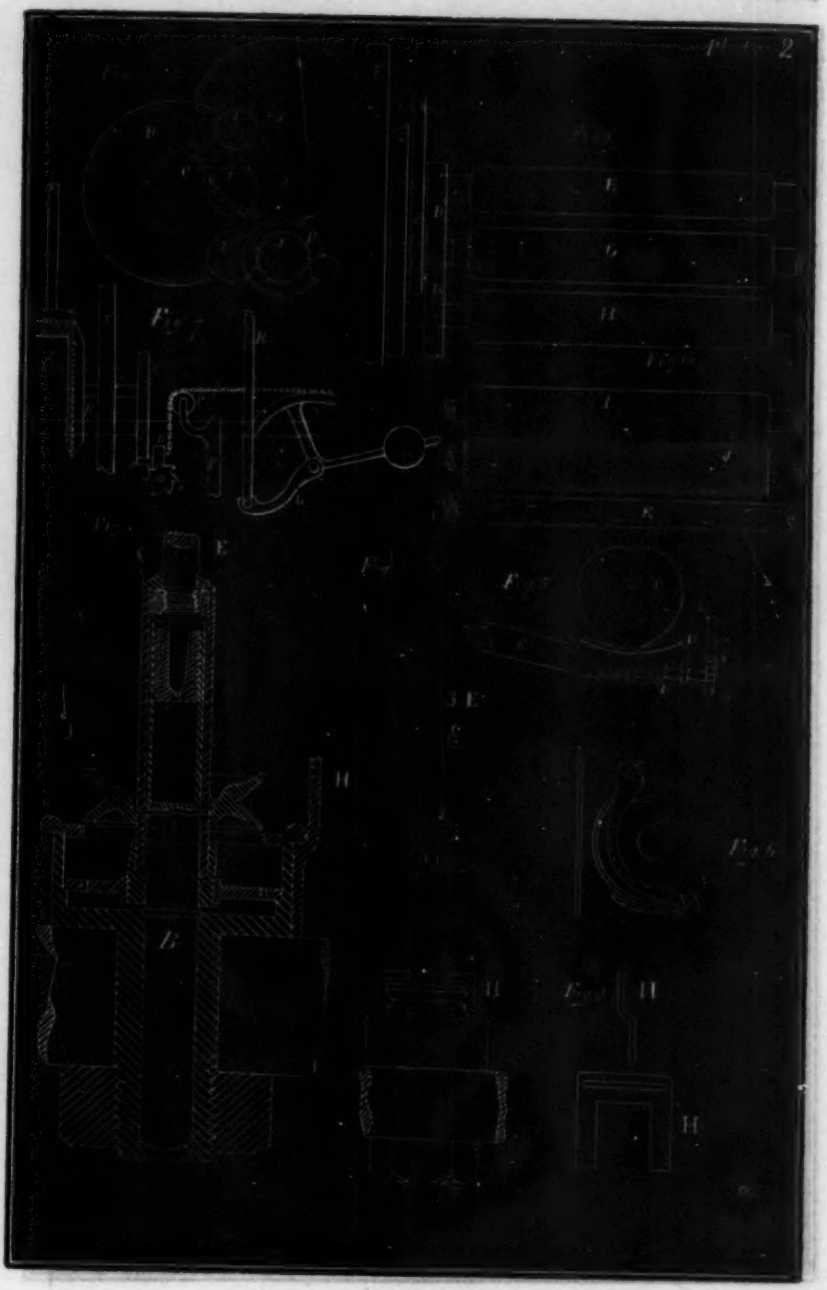
The invention of the method of spinning yarn by means of the ring frame, is undoubtedly due to John Thorp, of Providence, (although in some books it is attributed to John Sharp, of the same place; which however arose probably from careless writing); and in others to Mr. Jenks, of Pawtucket. In the Patent Office Reports, several patents are recorded as having been taken out by Mr. Thorp in 1829, in connection with cotton spinning machinery. In 1830 Mr. Thorp had one of his frames on exhibition in New York. It was somewhat similar to the frames now in use, in its general appearance, but was finished with only six spindles. It was driven by hand-power, and seemed to spin very nicely; the ring was quite different from those now in use, being furnished with a deep groove inside, into which a wire, bent to fit the ring, was set so that it could travel round in the groove. This inner ring of wire was furnished with a projection, to which the thread was attached. Mr. Thorp afterwards built some larger frames on this system, which however were not very successful. In 1833, Mr. Asel Lamphere, of Killingly, Connecticut, attempted to introduce the ring system of spinning into the various mills, and fitted over the old throstle frames; but unfortunately, almost all his attempts were failures, so that most of the manufacturers became very much prejudiced against the new system. In 1836, Mr. William Mason turned his attention to the subject, (in which, in fact, he had always been interested since its invention by Mr. Thorp), and being a very skillful mechanic, he finally succeeded in producing a ring frame which worked well, so that to him is really due the credit of being the first one to make the ring system of spinning a success; he also introduced the modern style of ring and traveler. Since that time, the ring frame has undergone scarcely any radical changes, although each maker has his own method of carrying out the details.

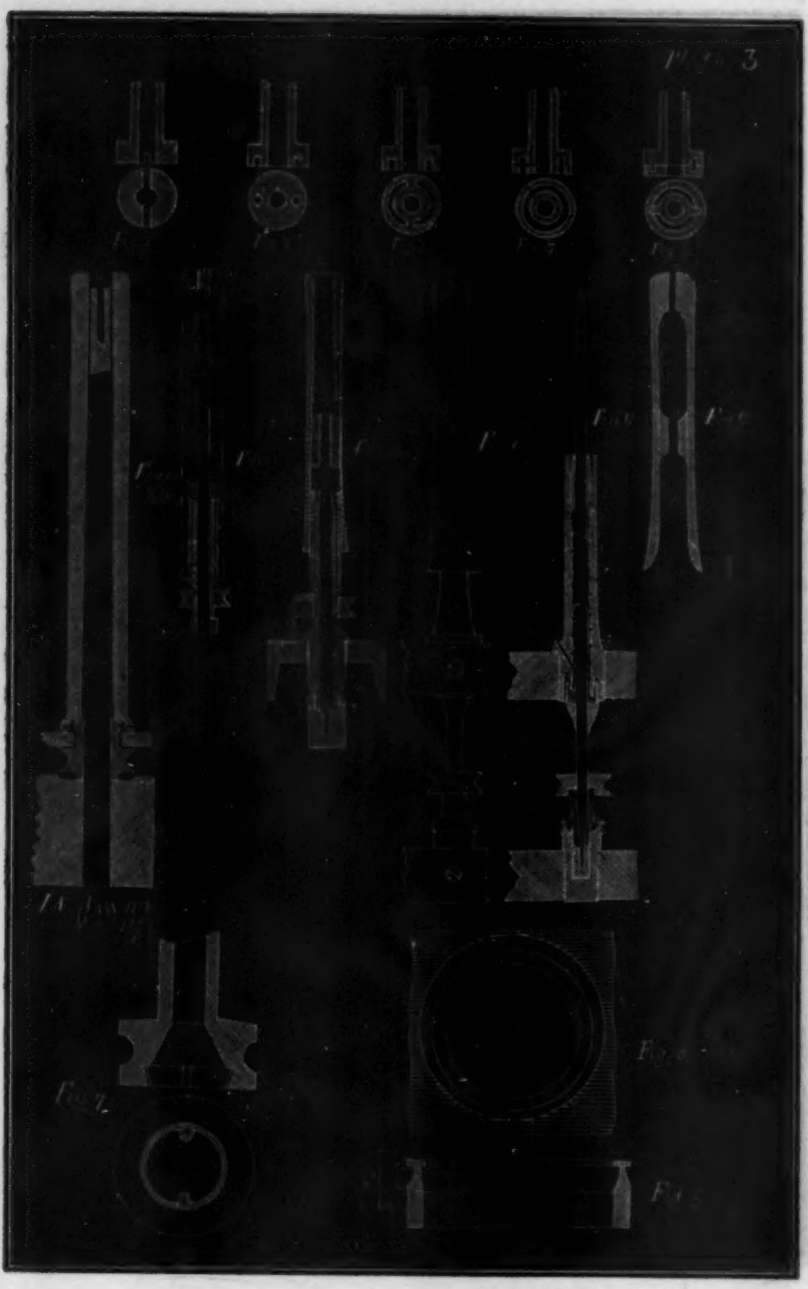
The general arrangement of the ring frame is shown in Plate I, Fig. 4, drawn from a frame, made by the Saco Water-Power Company, (although several of the details, especially the mechanism for lifting the ring rail, are omitted). The roving passes from the bobbins R, (which are so placed as to revolve freely, as the roving is unwound) through the three sets of rolls, R' R'' R''', and thence through the thread guide t, and traveler T, to the bobbin b.

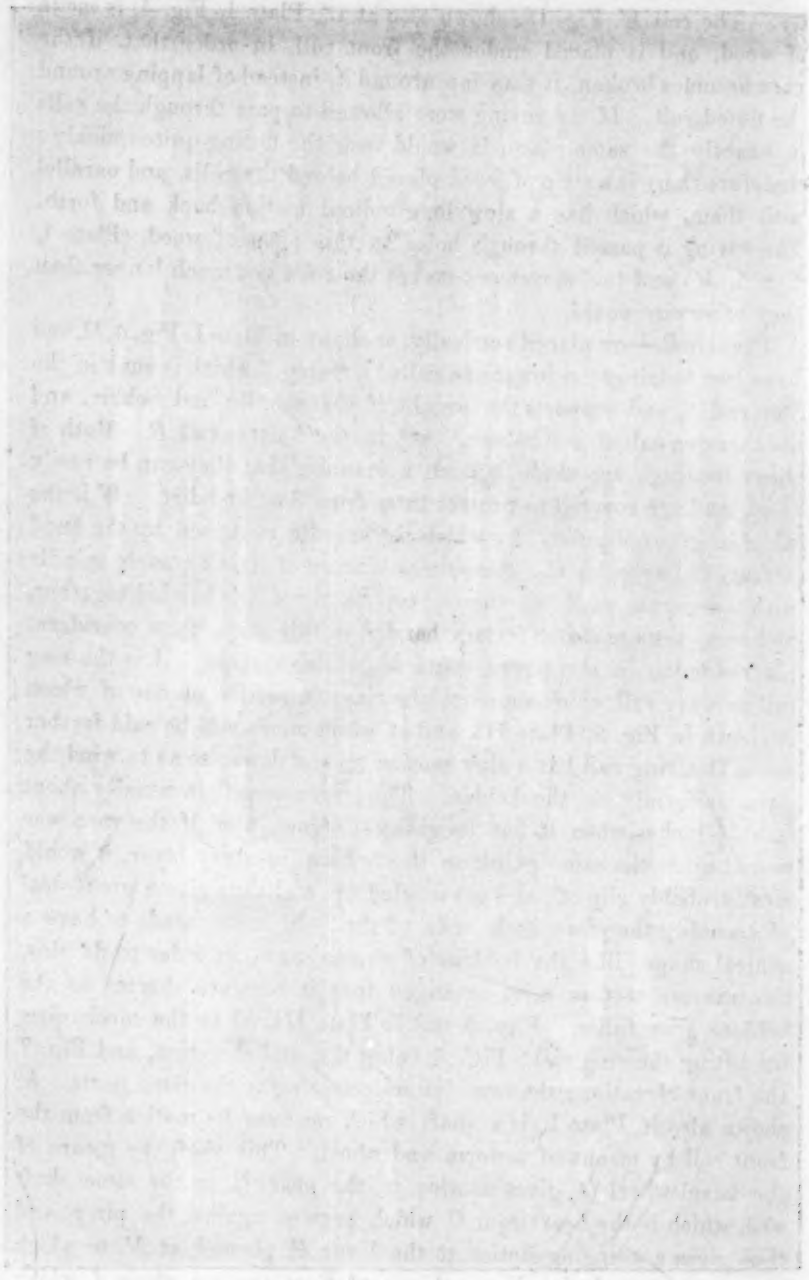
The method of driving the frame is as follows: In the lower part of the frame, and running the whole length of it, is a tin cylinder,

of which a very slight portion is shown at *C* in the drawing. This cylinder has a pulley at both ends; that at the farther end being driven by a belt from the shafting overhead, while the other one shown at *E*, drives the rolls. The cylinder itself drives the spindles by means of the bands or cords *o o o*. The twist pulleys *D D*, are driven from the pulley *E* by means of the band, as shown, *G* being only an idler pulley. The rolls and spindles are arranged in precisely the same manner on both sides of the frame, so that the same description will apply to both. In some frames, as for example, those built by the Lowell Machine Shop, the rolls are driven directly by gears from the cylinder, instead of by bands, as here shown. On the shaft with D, there is a small pinion called the twist gear, which drives the gear *F* on the front roll; on the same shaft as the gear F, there is a small pinion *D*, (see Plate II, Figs. 8, 9, 10, which show respectively an end elevation, plan, and front elevation of the rolls), which drives the stud gear *B*, which, as its name implies, is placed on a stud which is bolted to the frame. Connected with the stud gear, is the pinion gear *C*, which drives the back roll gear *A*. Thus it is evident that by changing the number of teeth in the pinion gear, any desired change in the relative speed of the front and back rolls can be made. The stud is, as I have before mentioned, secured to the frame by means of a nut, so that the necessary changes in its position can be easily made when the size of the pinion gear is altered. The middle roll is driven from the front roll by means of gears placed at the farther end of the frame; there is also an arrangement for adjusting the distances between the rolls, which is evidently necessary; for, if the front roll had a velocity equal to twice that of the middle roll, and the fiber was long enough to have the ends held by the two rolls at the same time, it would immediately be broken in two. The rolls must therefore be so adjusted, as to be just a trifle farther apart than the length of the fiber to be used. The rolls, as it has already been stated, consist of three sets, of two in each set; the upper ones, shown at *H G E*, Plate II, Fig. 9, and at *I I' I''*, Fig. 8, are made of iron covered with leather, and are held against the lower set by means of weights, so that the pressure on the roving and tension on the yarn is uniform, and may be adjusted for any pressure desired. The lower rolls, shown at *J*, Fig. 10, and *J J' J''*, Fig. 8, are made of steel and are fluted, so as to take a better hold of the roving, and feed it along with more certainty and uniform-









ity. The roll *K*, Fig. 10, shown also at *C'*, Plate I, Fig. 4, is made of wood, and is placed under the front roll, in order that, if the yarn becomes broken, it may lap around it, instead of lapping around the fluted roll. If the roving were allowed to pass through the rolls in exactly the same place, it would wear the fluting quite quickly; therefore there is a strip of wood placed behind the rolls, and parallel with them, which has a slow longitudinal motion back and forth. The roving is passed through holes in this piece of wood, (Plate I, Fig. 4, *H*) and this movement makes the rolls last much longer than they otherwise would.

The spindles are placed vertically, as shown in Plate I, Fig. 4, *ll*, and have two bearings; a lower one called a "step," which is sunk in the step rail *S*, and supports the weight of the spindle and bobbin, and another one called a "bolster," set in the bolster rail *B*. Both of these bearings are made in such a manner, that they can be easily oiled, and are covered to protect them from dust and dirt. *W* is the whirl or grooved pulley, by which the spindle is driven by the band *o*, from the cylinder *C*. Sometimes instead of driving each spindle with a separate band, as shown, two or three are banded together, and some tests made on frames banded in this way, show considerable reduction in the power required to drive them. *A* is the ring rail or wave rail which supports the rings, a section of one of which is shown in Fig. 9, Plate III, and of which more will be said farther on. This ring rail has a slow motion up and down, so as to wind the yarn uniformly on the bobbin. This "traverse" is usually about 5 or 5½ inches when it has its greatest value; now, if the yarn was wound up to the same point on the bobbin for every layer, it would most probably slip off, and get snarled up, and thus give a great deal of trouble; therefore both ends of the bobbin are made to have a conical shape, like the bobbins of roving, and, in order to do this, the traverse motion is so arranged that it becomes shorter as the bobbins grow fuller. Figs. 5 and 7, Plate III, show the mechanism for lifting the ring rail; Fig. 5 being the end elevation, and Fig. 7 the front elevation; the same letters referring to the same parts. *h*, shown also in Plate I, is a shaft which receives its motion from the front roll by means of a worm and wheel. This shaft, by means of the bevel wheel *G*, gives motion to the gear *B*, on the same shaft with which is the heart cam *C*, which presses against the pin *p*, and thus gives a swinging motion to the lever *E*, pivoted at *M*, to which the pin is attached. From this arm *E*, there is a chain *I*, which

passes over a pulley *P*, attached to the frame, and then is fastened to the arc *A*. On the same shaft to which the arc is fastened, is an arm to which a weight *W* is attached so as to keep the pin *p* constantly pressed against the cam. There is also another arm *L*, which supports the vertical rod *R*, which, passing up through the step and bolster rails, is attached to the ring rail, which it thus moves up and down. The ring rail, instead of extending the whole length of the frame, is divided in the middle, and each half has three lifting rods. Now, in order to cause the length of traverse to vary, the pin *p* is attached to a segment of a circle *D*, which has teeth on it fitting into a worm *B'*, on one end of which there is a star wheel *S*, the teeth of which strike against a piece *m* (which hangs from the step rail); when the lever *E* is lifted by means of the cam, this, of course, causes it to turn slightly, which, by means of the worm and gear, moves the pin nearer the pivot *M*, and thus by reducing the leverage, causes a corresponding reduction in the length of traverse.

Some spinners think it best in building the bobbin, to begin with the longest traverse and gradually diminish it, while others begin with a short traverse and gradually lengthen it; but either of these methods can be used by a suitable arrangement of the worm. Some frames also are arranged so as to begin at the bottom of the bobbin with a very short traverse, and every time the ring rail comes down not quite so far as it did before, and runs up a little farther, so that the bobbin is built up in a succession of cones somewhat similar to a mule "cop."

Mr. Evan Leigh, in his book entitled "The Science of Modern Cotton Spinning," makes the following remarks in regard to the ring frame: "The principal difference between the ring and flyer frame consists in dispensing with the 'flyer' and substituting a 'ring' fastened in the lifting rail, which is made to traverse for the filling of the bobbin. The winding on or drag is got by means of a flat steel

wire, bent in a half circular form, with the ends turned in, as annexed, which is dragged round on the top flange of the ring by the yarn passing through it on the way to the bobbins. These steel wires are called travelers, and the counts of the yarn to be spun, and the speed of the spindles regulate the weight and size of them. Owing to the great speed of the travelers (each one going through space at the rate of about 30 miles per hour), they wear out in six or eight weeks, when they have to be renewed. Going at the speed of 6000 revolutions per minute, each traveler will produce about 100 miles of

32's twist on the average, before it is worn out, which is equal to about six pounds of yarn; therefore, a concern spinning 10,000 lbs. of yarn per week, would consume about eleven gross of travelers, which would be about the same expense as the washer cloth consumed by the flyer throstles for the same quantity of yarn. The rings are generally made of fine-grained Low Moor iron, carefully finished, hardened and polished. Their sizes also need to conform to the different weights of yarn; and the finer and softer this is required to be spun, the smaller must be the rings. The average size of them is $1\frac{5}{8}$ inches diameter inside (see Fig. 9, Plate III). It is necessary to oil the rings three or four times a day, to prevent rapid wear, and reduce friction. If proper care be taken by attending to their lubrication, the rings will last from six to ten years. The bobbins are always driven directly by the spindle, either by being pressed on to a taper blade, or by a bead or braid, with pins fastened to the spindles, and fitting into corresponding recesses in the bobbins. The form of bobbin, in the first case, is a plain tube called a quill, which is generally $6\frac{3}{4}$ inches long, but varies with the length of the traverse. The size at the bottom is $\frac{7}{8}$ inch in diameter, and the size at the top 13-16 inch, the centre part where the yarn is wound being turned slightly hollow for holding it firmer. The tops of the bobbins are well rounded off. The holes in the bottom of the bobbins are $\frac{3}{8}$ inch in diameter, and near the top $\frac{1}{8}$ inch. (These dimensions are for the common spindle). The traverse is generally about $1\frac{1}{4}$ to $1\frac{1}{2}$ inches shorter than the length of the bobbins. There is a lengthening taper motion provided to secure the end layers, and prevent them from falling off. This kind of spinning frame runs very steady, owing to the well-balanced bobbin. The usual speed is 6000 to 8000 revolutions per minute of spindles for spinning No. 30's warp.* Still, there is an objection in piecing up, and in doffing, because the bobbins stick so fast on the spindles, that when required to be taken off, much time is lost in loosening them, thereby endangering the straining of the spindles, and the pushing off the yarn from the bobbins. Another form of bobbin is the straight tube, with bottom flange fitting loosely on the spindle, and being driven by the braids with pins."

(To be continued.)

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* This estimate of speed appears rather high, and from 5000 to 7000 revolutions per minute would probably be nearer the truth.

REPORT OF THE TRIAL OF THE STEAM MACHINERY OF THE UNITED STATES REVENUE STEAMER "GALLATIN,"

AT THE UNITED STATES NAVY YARD, BOSTON, MASS., IN THE MONTHS OF DECEMBER AND JANUARY, 1874–'75.*

By CHAS. H. LORING, Chief Eng'r, U. S. N., and CHAS. E. EMERY, Consulting Engineer.

[*Embodying a summary of the general results of experiments with the steam machinery of U. S. Revenue Steamers Rush, Dexter, Dallas and Gallatin.*]

The trial of the U. S. revenue steamers *Rush*, *Dexter* and *Dallas*, in the month of August, 1874—reports of which were transmitted to the U. S. Navy and Treasury Departments and shortly after widely circulated—furnished much valuable information as to the relative cost of the power in compound and non-compound engines, operated with the same and different steam-pressures at various degrees of expansion; but the comparison could not, with these vessels, be made in all respects complete for the reason that the cylinders of the compound engine were steam-jacketed, while those of the non-compound engines were not jacketed. At that time, however, new machinery was in process of construction for the U. S. revenue steamer *Gallatin*, of substantially the same power as that of each of the other vessels, the cylinder for which was steam-jacketed and the boiler designed to carry a high pressure of steam. Upon the completion of the *Gallatin*, it was arranged by the Navy and Treasury Departments to make a series of experiments with her machinery on the same system as the other vessels were tried, and under the general direction of the same persons, (the undersigned).

DESCRIPTION OF THE "GALLATIN."

The *Gallatin* is an iron screw steamer, with top-sail schooner rig, 147 feet long over all; 133 feet between perpendiculars at water-line, 23 feet beam, and 9 feet 6 inches depth of hold from top of cross floors to under side of main deck. The draught of water aft is about 9½ feet.

* Communicated to this JOURNAL by Chas. E. Emery, C.E.—ED.

The vessel was modeled and constructed by Mr. David Bell, of Buffalo, New York, in the year 1870, and by direction of the Department was at first fitted with a steering propeller and machinery adapted for operating the same. The vessel was rebuilt by the same party in the year 1874, and provided with a screw-propeller and new steam machinery throughout, (except surface-condenser,) designed by Charles E. Emery, consulting engineer; some details of engine being adapted to the style of the builder so that the patterns would be of service to him for future use. With the new machinery the vessel, which has an excellent model, steams readily upward of eleven nautical miles per hour.

MACHINERY.

BOILER.

The vessel has one boiler of the ordinary American flue and return tubular, circular shell type, constructed of heavy iron, and strongly braced, of the following general dimensions and proportions:

Length of boiler,	15 feet 9 inches.
Width of front and diameter of circular shell,	10 feet.
Height of boiler to top of circular shell,	10 feet 3 inches.
Diameter of steam chimney,	6 feet 6 inches.
Diameter of steam chimney-flue,	3 feet 6 inches.
Height of steam chimney above shell of boiler,	7 feet.
Number of furnaces,	2.
Direct flues: two of 28 inches, two of 18 inches, two of 12 inches diameter; all 3 feet 7 inches long.	
Return tubes 124 in number, each 3½ inches in diameter and 10 feet 9 inches long.	
Length of back connection,	2 feet.
Length of front connection,	2 feet 6 inches.
Grate surface,	55·25 sq. ft.
Cross area of tubes for draft,	7·20 sq. ft.
Water-heating surface,	1805·163 sq. ft.
Steam-heating surface,	105·311 sq. ft.
Ratio cross area tubes to grate surface,	7·68
Ratio grate to heating surface,	32·6
Ratio cross area tubes to heating surface,	250·98
Ratio cross area tubes to steam space, (9 inches above tubes),	52·2

ENGINE.

There is one main engine, of the inverted type, with steam-jacketed cylinder, 34·1 inches in diameter, with 30 inches stroke of piston. The comparatively short stroke was necessarily adopted in the design

to bring the main cylinder under the hurricane deck. Steam is distributed by a short slide-valve, arranged to cut off by lap at two-thirds of the stroke, and provided with adjustable cut-off plates sliding on its back. The air-pump is operated through levers from the main cross-head. The surface-condenser case does not form part of the engine frame, but is set on a separate foundation near the side of the vessel, and connected to air-pump by a pipe. The circulating pump is of the centrifugal type, of sufficient size to supply the necessary quantity of water at all times, with a speed of less than 200 revolutions per minute. It is operated by a vertical engine, with cylinder 4 inches in diameter and 6 inches stroke, directly connected to pump-shaft. The screw-propeller is 8 feet 9 inches in diameter, and has a mean pitch of 15 feet. The following are the principal dimensions of the engine:

Diameter of cylinder,	34·1 inches.
Stroke of piston,	30 inches.
Diameter of piston-rod,	4¼ inches.
Size of cylinder ports,	2½ by 27 inches.
Ratio of piston displacement to capacity of clearances and passages,	·0659

The boiler, steam-pipes, and cylinder are thoroughly covered with hair felt and canvas, and exposed parts in engine-room have an additional covering of either Russia iron or black walnut, secured by brass bands.

Steam for jackets is ordinarily conducted through a felted pipe from bottom of steam-chest to upper part of cavity in cylinder-cover. A second pipe leads from the bottom of the cavity in cover, upward and around to the side-jacket, which is in common with the jacket for bottom of cylinder. By this arrangement any water which collects in bottom of main chest or cylinder-cover is carried into the main jacket, from which all water is blown into hot-well through an intermediate vessel provided with a glass gauge. A small throttle-valve on the discharge-pipe from the vessel is regulated to show a water-level in the glass at all times, thus preventing loss of steam or an undue collection of water.

The boiler was designed to carry regularly a steam-pressure of 60 pounds. At the time of the trial it was nearly new and was worked part of the time with a steam pressure of 70 pounds, to correspond with that carried during the trials of the revenue steamers *Rush* and *Dexter*, previously mentioned.

MANNER OF CONDUCTING THE EXPERIMENTS.

The experiments with the *Gallatin* were made under the general direction of the undersigned, at the U. S. Navy Yard, Boston, Mass., in the months of December, 1874, and January, 1875, and the system adopted was similar to that used during the trials of the U. S. revenue steamers *Rush*, *Dexter* and *Dallas*, made under the same general direction in the month of August, 1874, full particulars of which may be found in the report of same, dated October, 1874. The following officers were detailed by the Navy and Treasury Departments, respectively, to take immediate charge of the experiments, viz: Chief Engineers Charles E. De Valin and Edward Farmer, U. S. Navy; Chief Engineers Chas. A. Satterlee and Chas. H. Ball, U. S. Revenue Marine; Passed Assistant Engineer W. D. Smith and Assistant Engineer J. A. Tobin, U. S. Navy; and First Assistant Engineers John T. Collins and J. A. Severns, U. S. Revenue Marine. Each chief engineer with an assistant stood regular watches while the experiments were in progress, and signed the original log. One of the undersigned was at all times on the vessel or within call. The computations were made by Passed Assistant Engineers Greenleaf and Brosnahan, and Assistant Engineer Gates, U. S. Navy, and Mr. E. Hugentobler in behalf of the U. S. Revenue Marine.

The experiments were made with the vessel secured to the wharf.

The coal, which was anthracite of fair quality, was broken on the wharf to proper size, (the vessel's bunkers having been closed and sealed) and filled into bags to a certain weight.

The bags were sent on board when ordered by the senior engineer on watch, he making record on the log of the number of bags and the time of receipt, a similar record being made by one of the men on the wharf. At the end of the hour the number of bags of coal actually put on the fire was reported from the fire-room and entered in the appropriate column. The several records agreed with each other, and the total amount expended corresponded with the total number of bags filled on the wharf. The ashes were measured into buckets, of which the mean weight was ascertained and tallied as they were hoisted out. They were afterward weighed in gross on the wharf and the two accounts found to agree substantially.

The feed-water was measured after its delivery from the surface-condenser, and before its return to the boiler, in the tank used during

the previous experiments, which was constructed of boiler-plate and was divided by a partition of same material into two equal parts. In the upper edge of the partition-plate was cut a rectangular notch, eight inches long, by which the height to which each half of the tank could be filled was determined. The mean of the weight of water which the half tanks contained was 1129½ pounds at a temperature of 72 degrees Fahrenheit. In the computation of each experiment the weight of water is reduced to correspond with mean temperature. The measuring tank was erected on the hurricane deck, just abaft engine room skylight, and covered by a temporary cabin, in which was a small stove with which the assistant could regulate the temperature of the inclosure at will. [The previous experiments were made in the summer, and the tank was sheltered from sun and rain simply by the deck-awning.]

One of the feed-pumps was disconnected from the check-feed valve and arranged to discharge the condensed water from hot-well into a small receiving-tank supported above the measuring tank. The receiving-tank had on its bottom two cocks, one over each half tank, so that either could be filled from it at will.

The other feed-pump had its suction-pipe detached from the hot-well and connected with the bottoms of the two half tanks through a cock on each, so that the contents of either could be drawn out and discharged into the boiler.

The method of measuring the water and recording it was as follows: One side having been filled, the cock over it on the receiving tank was closed, and the other over the empty half opened. When the water in the full one had settled to the height of the edge of the notch, its cock in the feed-pipe was opened and its contents pumped into the boiler, (care being taken to empty one in less time than it required to fill the other); when empty, its feed-cock was closed. When the water in the tank being filled reached within a few inches of the notch, a gong in the engine room was sounded to call attention; and when it reached the notch, the gong was struck twice; at this instant the assistant engineer in the engine room noted the reading of the counter, and an attendant in the fire room noted and reported the height of water in the glass gauge on the boiler, as shown by a scale of inches secured to it. The attendant at the tank also noted the time of filling and the temperature when the tank was half emptied. After entering the number of the counter in the log, the assistant en-

gineer ascertained the numerical difference between that and the preceding entry, and if it was far from the average, its cause was sought for.

By this system of checks all errors of record could be detected, and it was possible to preserve and utilize any continuous run which came to an end through derangement of the engine. All parts of the tanks, pipes, and cocks were plainly visible to the eye, and had any leaks occurred therein they must have been detected.

The water from steam-jacket, steam chest, etc., was measured as follows: The discharge pipe from the drip vessel, previously mentioned as connected with the lower part of steam-jacket, was led through the coil of an ordinary ships' distiller, the coil being kept cool by allowing circulating water from the condenser to flow through case surrounding same into the bilge. This formed a refrigerating apparatus, and the water from jacket, etc., being cooled thereby, was permitted to flow freely into an open tank set on a scale. When the tank was full the discharge from refrigerator was temporarily shut off, and the weight of tank and water noted. The tank was emptied by suction through a pipe dipping therein and connected with condenser. The suction-pipe was provided both with a stop and an air-valve, the latter being opened when tank was filling, to prevent any water being drawn into condenser at that time by leakage of the former. The water being delivered in condenser formed part of that received in hot-well, and was therefore charged in determining the cost of the power.

The surface-condenser, boiler, and steam and water connections proved quite tight, so that the water lost in the circulation to and from the engine was very slight, and only during the longer experiments was it found necessary to add water to maintain the average level in boiler. The small amount thus required was run from the hydrant into the tank which was at the time being filled, and was therefore measured and charged in the cost.

Indicator diagrams were taken every twenty minutes throughout the trials, and the data for the usual columns of the log immediately after filling a tank, or not less than three times an hour, in all cases. The indicator employed was one of those used during the trials of the other revenue steamers above mentioned, which again proved correct upon being tested.

The results of the experiments are shown in the first of the accompanying tables, lines 1 to 44 inclusive, containing the several

observed and computed quantities upon which the performances, set forth in the remaining lines, are based.

As indicated by the general headings, a series of experiments was made at the several approximate steam pressures of 12½, 40 and 70 pounds, both with and without steam-jacket in use, and for the higher pressure with and without vacuum. In some cases also the steam was throttled, in others the link was hauled up and the steam cut off by the lap of the main valve. The effect of using steam in jacket of higher pressure than that in cylinder was also tried, and the effect of draining the main steam chest both with and without use of steam jacket.

To ascertain the evaporative efficiency of the boiler, the machinery was operated continuously for 48 hours with an approximate steam pressure of 70 pounds. During the first 24 hours of this period the steam-jacket was in use, and the run, for this time, is designated No. 38 in Table. For the last 24 hours the steam was shut off the jacket and the pipes disconnected; for this time the run is designated No. 33 in Table. The evaporation is calculated separately from each of these runs on the basis of the coal charged in log for the respective times, and it will be seen in line 55 that the results correspond closely; run No. 38 showing an evaporation from observed temperature and pressure of 7·34 pounds water, the rate of combustion per square foot of grate being 15·3 pounds per hour, while in run No. 33, with the increased rate of combustion of 16·3 pounds, the evaporation was 7·26 pounds of water. The two runs, 38 and 33 (though the records are arranged for classification under different heads) were actually consecutive, the latter being held to commence when steam-jacket was shut off, without any stoppage or other change of condition. The runs taken together can then, as respects evaporation, if desired, properly be calculated as one of 48 hours' duration.

In all cases, when steam was shut off jacket, a joint was broken in the jacket connections to let in air and prevent the possibility of any leakage being undetected.

For the remaining experiments, which were each but two hours long, approximately, the water measure was used to determine the cost of the power, as the coal could not be distributed accurately for such short intervals.

By adopting a duration of two hours for a majority of the experiments it became possible to obtain far more information in the limited

time than in any other manner, and it is believed that the result can be depended upon fully as well as if the experiments were each of 48 to 96 hours' duration and fewer in number. In determining the variation due to changes of condition, it is important that all conditions remain uniform during each experiment, which is practicable for short but not for long runs. It may be claimed that a mistake in an observation will affect a long run less than a short one, but the fact seems to be that any important error will, for a short run, give such a wide difference of result, compared with other runs, as to indicate the probability of a mistake at once. We acknowledge that a single short run may be of little value; but by making a series of such runs, in which but one condition is changed slightly for each experiment, the results of the several experiments may be compared together, (by plotting the same in a curve, for instance), when a general correspondence will usually be observed, which will enable errors in observation or calculation to be detected, and insure a degree of accuracy generally impracticable for a long run, where an error affects the final result only and may never be discovered. It will often occur, however, that the average cost of the power will be less for short runs than for long ones; the short runs giving the accurate maximum results due to uniform conditions, which form the true basis for scientific comparison, while for long runs the results, at the best, can only be averages of maximum and inferior results. The maximum can be obtained permanently by keeping the conditions uniform —for instance, the economy due to a high steam pressure is obtained on land by using large boilers and automatic regulating devices. The short runs may then, in general, be considered as showing what is *possible* with *proper* apparatus; the long ones what is *possible* continuously with the *particular* apparatus tested.

In working out the experiments a number were found not to correspond with others of the same series, and in a few of them, errors of observation or faults with the indicator diagrams were discovered which necessitated their rejection. Those in which no errors could be detected have been retained, as we have not felt authorized to reject any without cause, though most of the discrepant ones were made during the first few days, before the entire force had become thoroughly acquainted with the duties. In two experiments, Nos. 10 and 12, the atmospheric line was misplaced on the diagrams, but, the latter being otherwise perfect, the misplacement was corrected by com-

parison with other diagrams. The most important difficulty with the diagrams was, however, caused by the sticking of the indicator-piston from the action of the lubricants in main cylinder. The difficulty was known and provided for by regular periods of cleaning indicator, but it appears that the precaution was neglected occasionally, particularly by one assistant, till the distortion of diagrams could be seen by the eye without using the scale. The experiments with faulty diagrams were rejected, except seven of the short ones, in which the action had only progressed sufficiently to change the position of the vacuum line. These experiments, which are numbered, respectively, 13, 30, 34, 37, 40, 41, and 42, and distinguished by an asterisk in Tables, have been carefully corrected by comparing the diagrams and the records of vacuum thereon with others taken under similar conditions.

We feel assured that many of the contradictory results of experiments heretofore published have been due to mistakes in observation or faults in the working of instruments, which were either undiscovered or neglected, and have therefore felt it our duty to state fully what occurred during these experiments, notwithstanding the interest manifested by the officers engaged, the system of checks and counter-checks, and in general, the extraordinary care taken to insure accuracy.

It is evident, however, that the character of the results is sufficiently indicated by the thirty-six experiments, about which there is no question. The seven others referred to have been corrected, we think, on an accurate basis, and retained for what they are worth, simply to preserve the symmetry of the series of runs.

To determine what may be called the quality of the steam—in other words to ascertain whether it was moist, saturated, or superheated, and in what degree moist or superheated—a calorimeter was erected in the gangway abreast of engine room, consisting of a large tight barrel set on a platform scale, with a screw propeller mounted inside and near the bottom of the barrel on a vertical shaft, terminating at the top with a crank. In the barrel was hung a large thermometer. To the bottom of the throttle-valve chest, on side of main steam chest of engine, a connection one inch in diameter was made, the pipe running up inside to the height of one of the ports admitting steam to main chest, which pipe connected through a valve to a short piece of hose, which was warmed by blowing steam through the same

just previous to an experiment. The barrel being filled with water, its weight and temperature were accurately ascertained, and the hose, with steam at the time escaping therefrom, quickly thrust in the water, the steam turned on more fully, and the propeller revolved. With the latter a decided circulation could be easily obtained, which immediately equalized the temperature. When the temperature had risen to the degree desired, the steam was partially shut off, the hose removed, and a final observation of weight and temperature immediately taken.

Table showing results of Experiments with Calorimeter.

1	2	3	4	5	6	7	8		9
Designation of Experiments.	Steam pressure in boiler above atmosphere.	Original weight of water in Calorimeter.	Weight of steam and water added to Calorimeter.	Temperatures.			Percentage of moisture in steam.		Number of degrees superheated.
				Initial.	Final.	Range.			
	Lbs.	*Lbs.*	*Lbs.*	*Deg.*	*Deg.*	*Deg.*		*Averages.*	
1	67·6	345·750	21·00	38·50	106·50	68·00	—1·96		
2	70·1	334·625	20·50	49·00	113·50	64·50	4·80		
3	64·1	352·875	22·75	39·75	110·40	70·65	·05	1·58	.....
4	68·5	354·625	23·50	39·25	111·12	71·87	1·44		
5	60·5	339·000	22·50	34·50	105·50	71·00	3·60		
6	11·8	357·500	13·00	61·12	101·40	40 28	—2·34	—2·34	46·0
7	43·8	355·500	20·25	39·50	102·75	63·25	—1·37	—1·02	19·3
8	42·8	345·250	23·75	37·00	112·30	75·30	—0·67		

These experiments were made on different days with different steam pressures, and at different intervals in relation to the time when fires were cleaned. The results of the trial are shown in the foregoing table in connection with the data from which they were calculated. The steam pressures are those in the boiler, and as the steam pipe was large and short, it is believed that there was no considerable reduction of pressure in the throttle-valve chest. The metal propeller and shaft being immersed in the water were subject to the same changes of temperature, and for simplicity their influence on the result was estimated on the basis of their specific heats and ascertained

to be equal to that of one and one-half pounds of water, which quantity has been added in each case to the actual amount of water in calorimeter. The quantities in column 8, showing the percentage of moisture in the steam, are negative for experiments in which the steam was superheated, that form of expression being used for convenience in determining the averages for the several approximate pressures.

The second of the accompanying tables is a summary of the results of experiments made with the revenue steamers *Rush*, *Dexter*, and *Dallas*, referred to at the beginning of this report, and of the experiments with the *Gallatin*, hereinbefore set forth. The general arrangement of the table will be understood by inspecting the headings in connection with the descriptions of conditions, etc., written opposite the lines. The principal quantities influencing the results have been copied from the original detail tables, and others have been added, showing the weight of water required to be condensed per hour to supply the mechanical equivalent of heat for the total work, and the influence of same on the calculated cost of the power. The calculations are made for the total work done both before and after the point of cut-off, without discussing the correctness of the system, but simply to correspond with similar quantities heretofore published by others in connection with experiments of this character.

The actual weights of feed-water used per indicated horse-power per hour are shown in column 20, and may be used for comparing the cost of the power in the various engines under the several changes of condition. Since, however, the evaporation of the water during the experiments with the higher steam pressures required a little more heat than with the lower, there has been presented in column 23 a comparison of the cost in pounds of coal per indicated horse-power calculated from the cost in water per column 20, but allowing for the difference in pressure at which the evaporation took place; the uniform basis of calculation being that each pound of coal imparted to the water 9265·34 heat-units, which is equivalent to an evaporation of 8½ pounds of water per pound of coal from a temperature of 120°, and at a pressure of 70 pounds above the atmosphere, a rate practicable in good marine boilers, and readily exceeded in land boilers. The quantities in line 23 show, then, the true relative cost of the power in fuel on a uniform basis; and for convenience, column 24 has been added, showing relative costs on same basis, with experiment

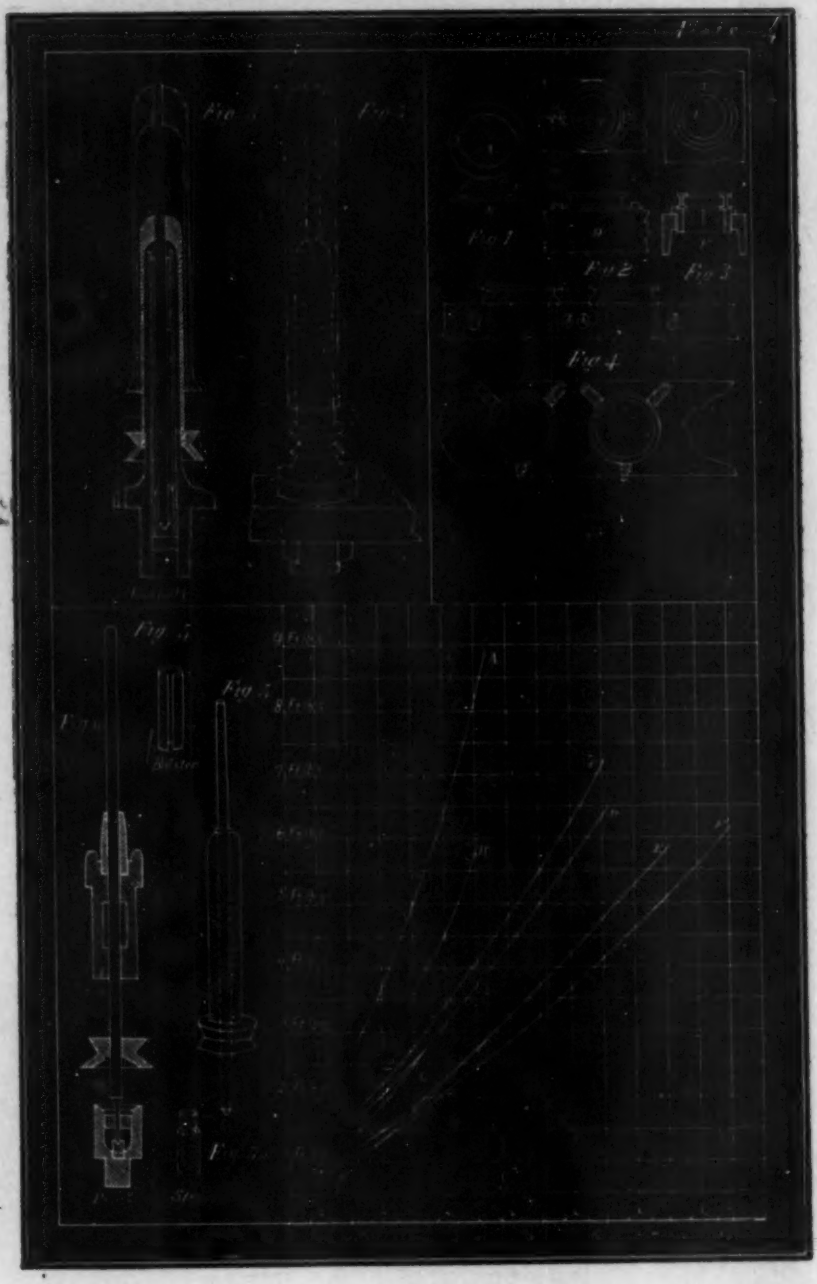
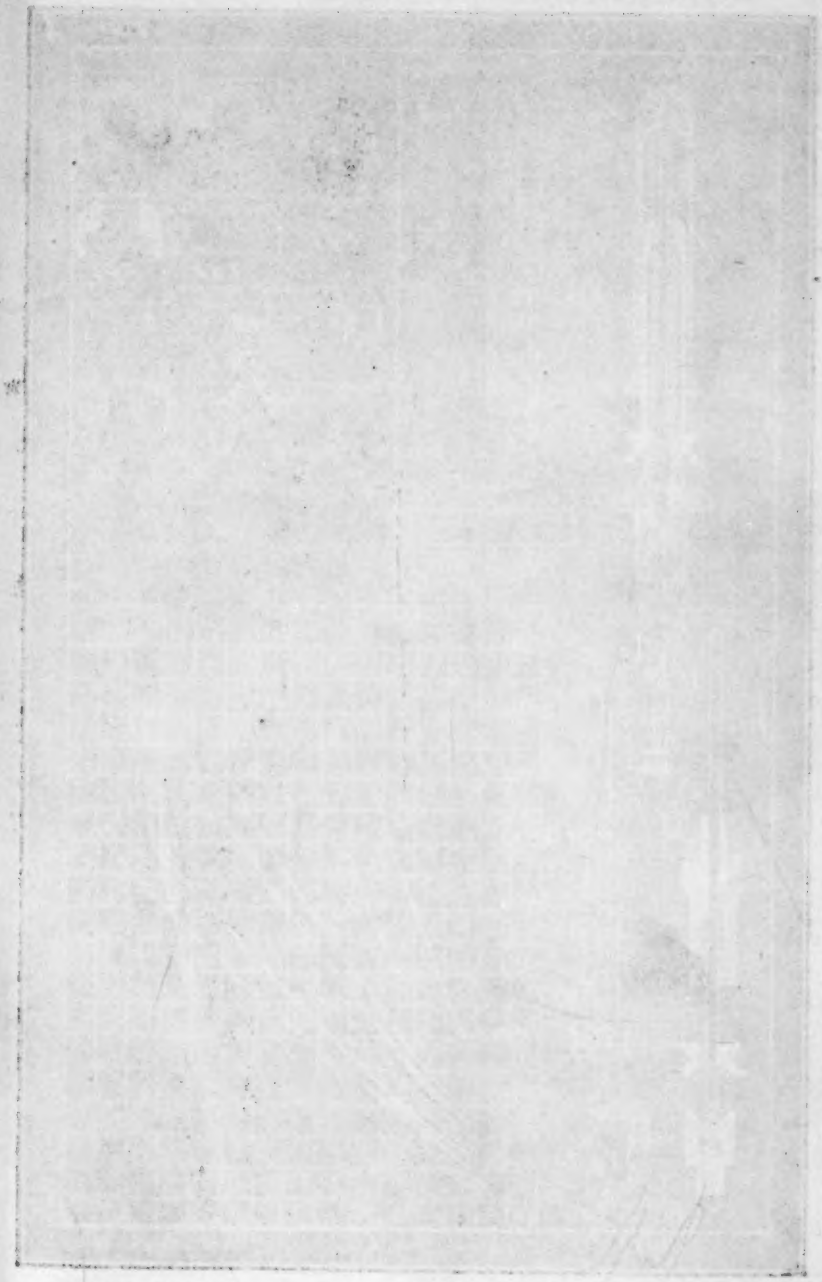


Fig 1
Fig 2
Fig 3
Fig 4
Fig 5
Fig 6

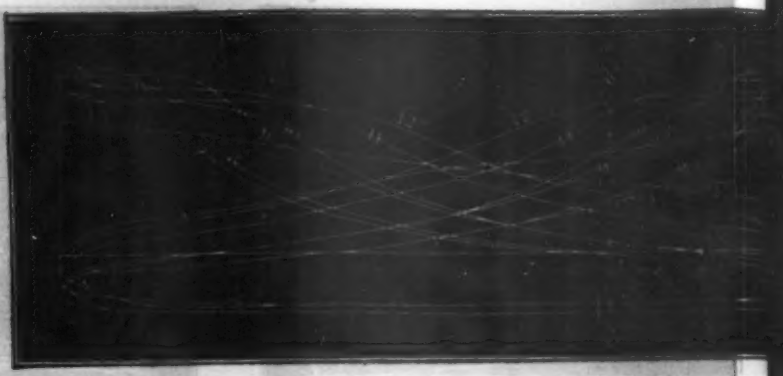


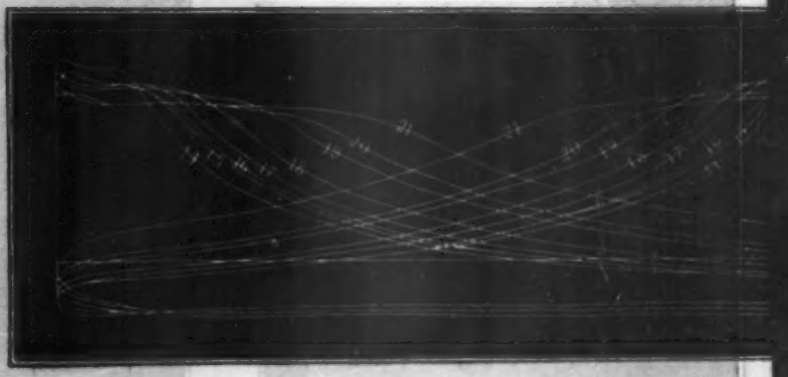
INDICATOR DIAGRAMS

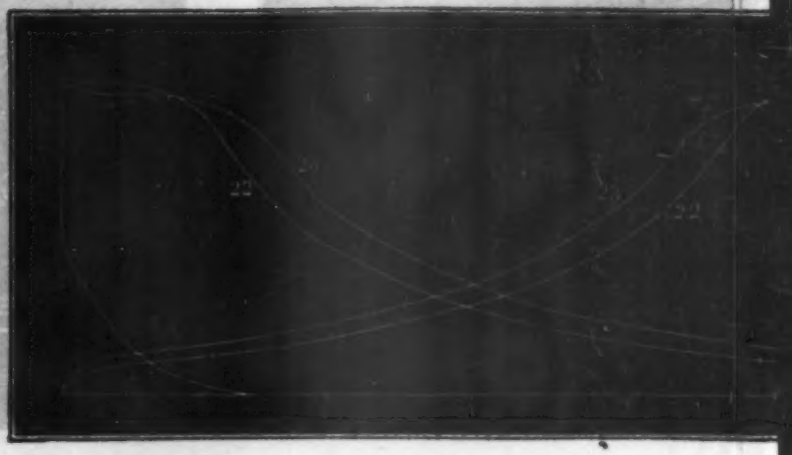
To accompany report of Experiments made with the Steam Machinery of the U. S. Revenue Steamer GALLATIN, under the general direction of Chief Engineer Chas. H. Loring, U. S. N., and Chas. E. Emery, Consulting Engineer, U. S. R. M.

The numbers on diagrams refer to the numbers of experiments as written in first table, and in Series II of Summary.

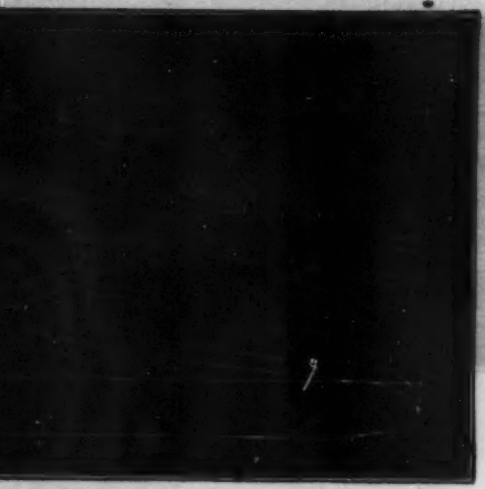
Scale of Indicator, 16 pounds per inch.

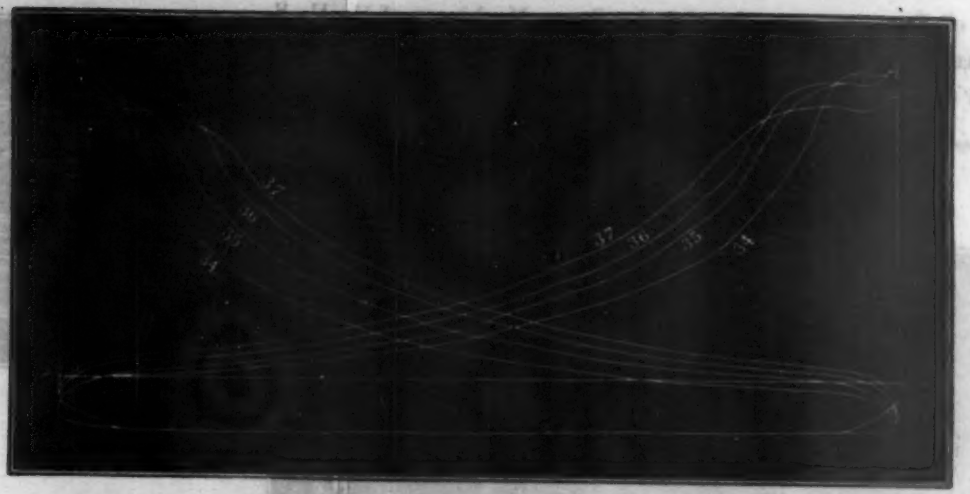


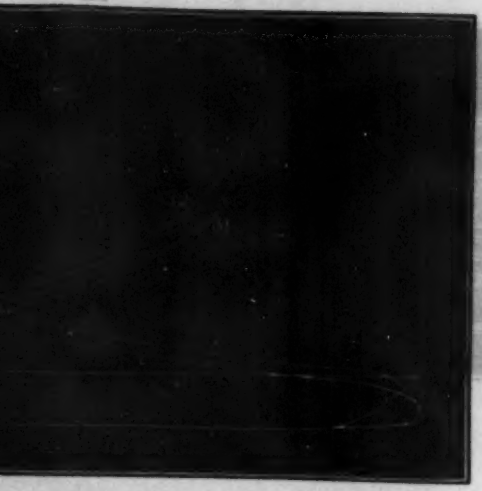


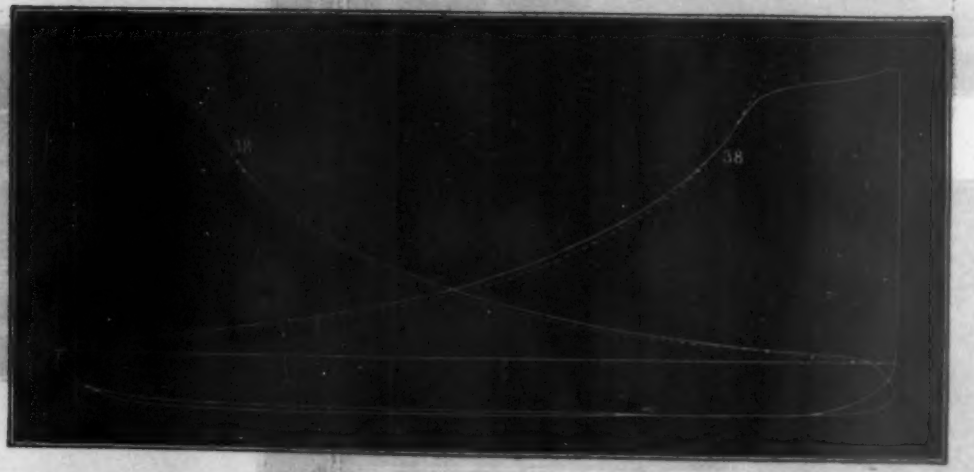


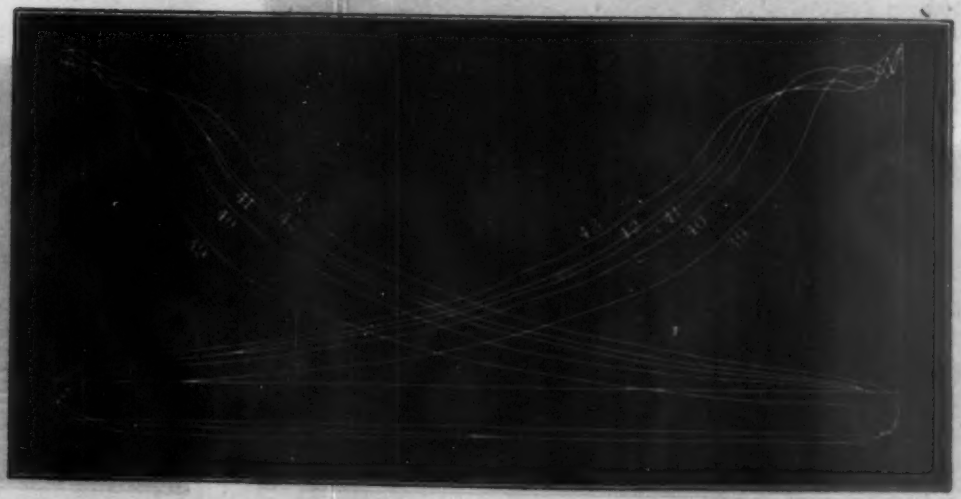
40 POUNDS PER INCH.

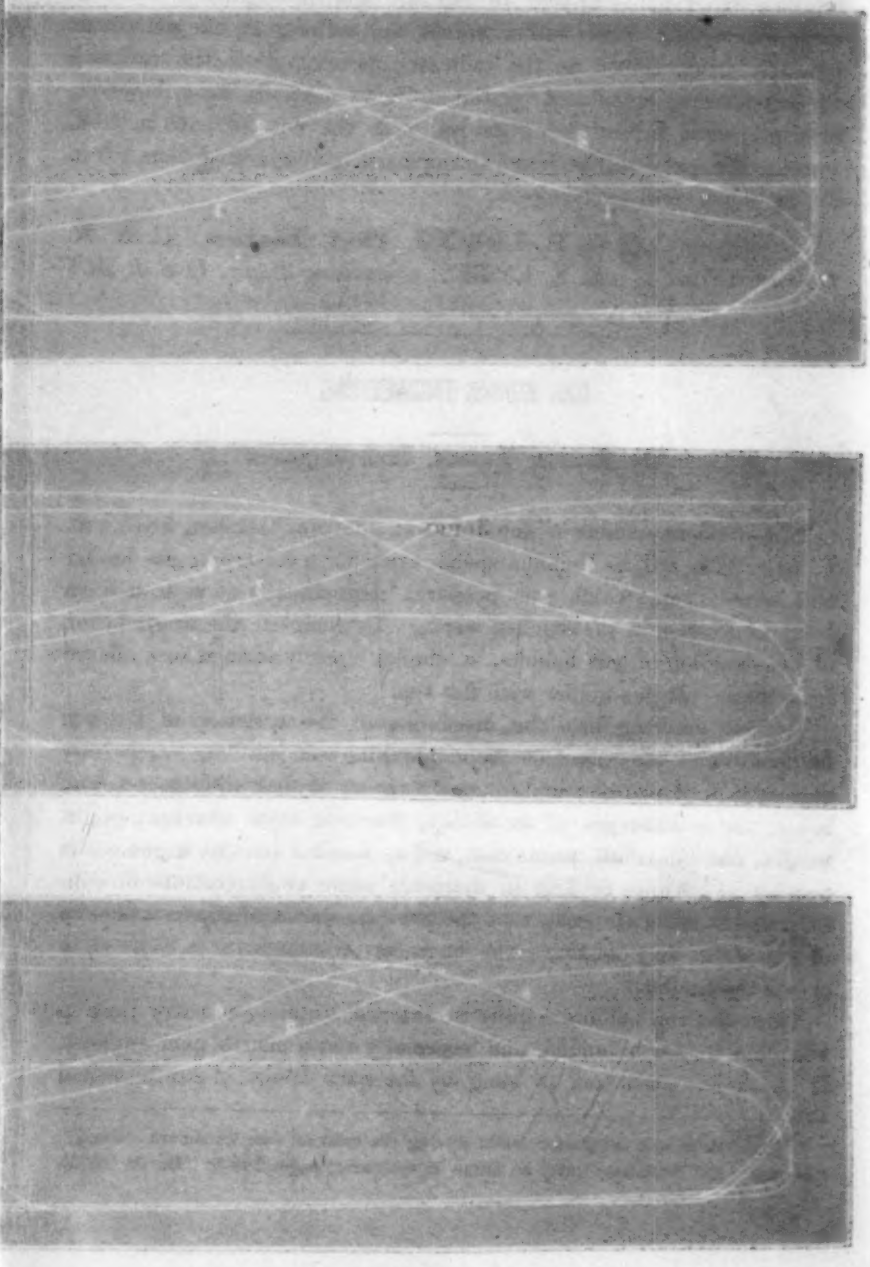












No. 1 of first series as unity. No attempt has been made to present in the summary either the relative cost of the total or of the net horse-power. The former is unnecessary for ordinary investigations, and late experiments appear to indicate that in engines of substantially similar size, with similar valves and valve-gear, the net power is nearly proportioned to the indicated power. Both the total and the net powers, calculated by the ordinary methods, have, however, been presented in the detail tables, with the cost of each in feed-water. Annexed will be found specimens of indicator diagrams, taken during the several experiments.

C. H. LORING, *Chief Engineer, U. S. N.*
October, 1875. C. E. EMERY, *Consulting Eng'r, U. S. R. M.**

GAS WORKS ENGINEERING.

By ROBERT BRIGGS, Civil Engineer.

In a previous number of the JOURNAL (that for October, 1875, vol. C, page 242), will be found a specification for a telescopic gas holder with crown top, which was prepared methodically so as to make a full specification in the briefest words. To complete the presentation of construction of gas holders, a similar specification is now offered for a single-lift gas holder with flat top.

Without entering into the discussion of the question of flat top holders (which the writer has been planning and building extensively since 1851), it will be simply stated that at 60 feet in diameter, and below, the advantages of durability, freedom from accident, light weight, and above all, prime cost, are so decided that no argument is necessary. Above 80 feet in diameter some considerations of construction so affect the cost, that the predispositions of superintendents of gas works may influence the engineer or contractor in favor of a crown top holder.

These flat top holders require no internal framing to carry the top when the holder is landed, and especially not a central pier support. If the top is permitted to hang by the curb freely, it can be relied

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* NOTE.—Indicator Diagrams taken during the trial of the Steamers "Rush," "Dexter," and "Dallas," may be found in vol. xcix, pages 204–5, (March, 1875).

upon to carry, not only its own weight, but also the weight of a foot of wet snow; 8 or 10 inches of water in the form of a plano-convex lens; 15 or 20 men; or any other load of necessary character, and yet not be strained by tension on the iron of the sheets, between the rivets, above the working tensile strength of 11,000 to 12,000 lbs. per square inch.* The only disturbance of the parts of such a holder when it lands, is the falling in of the top carriages at that time, so that the wheels leave the guides; but upon inflation of the holder this derangement adjusts itself, and the rollers find their place anew. This subject of the strength of the flat top crown may be reverted to at another time.

As the contents of an open top cylindrical vessel bear a maximum ratio to the surface of the sides and bottom, (the envelope being supposed to be of equal thickness throughout), when the sides are one-fourth of the diameter; so there also exists a maximum ratio between the contents and the weight of the envelope of a gas holder; in which the crown has one thickness and the sides another, with curbs, legs and all considered; which ratio determines the proper height of the side of a gas holder as compared to its diameter. In the gas holder question, the tank and its cost, form a part of the problem, and the proportions should be fixed so as to give the largest contents for gas for the smallest expenditure on holder and tank together. It has been found that if the height of sides be taken to be $0{\cdot}28d + 3{\cdot}2$ that a scale of heights for given diameters ($= d$) will be found, which scale, a comparison of examples actually taken out, will be seen to nearly fulfill the conditions; as follows:

Diameters,	8,	10,	12,	14,	16,	20,	24,	28,	32,	36,	40,	45,	50,	60.
Heights,	5·44,	6·0,	6·56,	7·12,	7·68,	8·8,	9·92,	11·04,	12·16,	13·28,	14·40,	15·8,	17·2,	20·0

It will be found practicable to bring the weight of the iron work of holders built to these proportions to $2\frac{1}{2}$ inches of water pressure, and when the thicknesses, etc., thus found, are examined, they will exhibit such dimensions as will satisfy the most critical in proportion of parts. The following specification shows the dimensions for a 60 ft. holder.

SPECIFICATION FOR A SINGLE-LIFT GAS HOLDER.

FLAT TOP CROWN.

For _____

Working contents of holder 5654 cubic feet. (Allowing six inches submersion of sides when up.)

* The assumed loads for top of holder have been taken as maximums of actual occurrence, by accident or otherwise.

This holder will have a weight of 2¼ inches water pressure.

CROWN.

Curb Sheets, { Width, 2 feet 0 inches. Thickness,* No. 10.

Remaining sheets of crown, No. 12.

SHELL.

(Upper and Lower) Curb Sheets, { Width, 2 feet 0 inches. Thickness, No. 13.

Intermediate sheets, thickness, No. 15.

Upper curb, angle iron, $4'' \times 4'' \times \frac{7}{16}''$.

Lower curb, angle iron, $3'' \times 3'' \times \frac{3}{8}''$.

12 legs, T shape to be built of $2 - 1\frac{1}{2}'' \times 1\frac{1}{2} \times \frac{3}{16}''$ L with a web of $5'' \times \frac{1}{4}''$ flat, and to have a backing plate of flat iron $3\frac{1}{4}'' \times \frac{1}{8}''$ on outside of section, countersunk riveted.

12† chord ties, $2'' \times 1\frac{1}{4}''$ flat iron, to lower curb, running from each leg to foot of second leg, and riveted to curb and at intersections.

The splices, gussets, thickening plates (where brackets are attached), etc., to be of suitable dimensions. Manhole on crown of holder.

6 carriages, with base plates and guide wheels on top of holder.

12 carriages, with rollers on lower curb.

Two coats of metallic paint to be applied, one before shipment and one after erection; the latter coat on inside and outside of holder.

HOLDER FRAME.

6 cast iron columns, with base plates, placed at equal distances around circle formed by the tank, which shall be 62 feet 2 inches inside diameter.

The entablatures to be 1 foot 8 inches high, and securely clamped to capitals.

6 wrought iron lattice girders, 1 foot 8 inches high, connecting columns together at top, composed of two pieces of angle iron.

2¼ inches × 2¼ inches × $\frac{5}{16}$ inch at top and bottom with flat iron, 1⅜ inches × ¼ inch, crossed and riveted to angle iron, and at intersections.

Girders firmly bolted to entablatures.

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* Refers to Birmingham Wire Gauge.

† Chord ties are not requisite except in windy locations.

12 tank guides, of cast iron, with hoop iron anchor strips, to be built in brick work of tank.

Each column to have 2 foundation bolts, 1¼ inches diameter, and 6 feet 6 inches long, to be built in tank wall, and secured by cast iron washers, 12 inches × 12 inches × 1¼ inches thick in centre of washer.

Cast iron pipes, as per drawing, for 8 inch inlet and 10 inch outlet to tank of holder, with two drip boxes, 14 and 16 inches diameter × 27 and 36 inches deep, with hand pump for same.

Two coats of metallic paint to be applied on all exposed surfaces of the holder frame, one before shipment and the other after erection.

The whole of the work specified to be delivered at.....

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.....

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It is stipulated that the tank shall be kept dry by the gas company, and that lumber for scaffolding shall be provided by them. The erection of and removal of which shall be done by the builder, and the material shall be used without unnecessary waste, and, on completion of the holder, be carefully piled upon the adjacent ground.

All carpenter work, masonry, excavation, and the placing of inlet and outlet pipes, and setting of foundation bolts and washers, and of tank guides in wall of tank, shall be done by the gas company.

All material to be of the best quality, and the work done in first-class manner, subject to the inspection, and to be completed to the satisfaction of the engineer of the gas company.

Steel Rail Rolling in South Wales.—The two longest steel and iron rails ever rolled in South Wales were rolled in the Goatmill Right (Dowlais ironworks) a short time ago. One steel rail measured 105 ft. 2 in., and the other 107 ft. 9 in. The longest previous to these was rolled at the Ebbw Vale Works, and was 89 ft. only. Again, in the Bessemer department they turned out, (with one pit, two 5-ton converters—one cupola only working at the time), for the four weeks ending Saturday, December 21, no less than 460 casts; each cast containing 5 tons 16 cwt. of pig iron. This will give an average of 10·5 casts with one cupola per twelve hours, which is by far the greatest number upon record. It should be stated that on Saturday they only have five casts, so that the men may finish by noon.

Chemistry, Physics, Technology, etc.

ON THE DEVELOPMENT OF THE CHEMICAL ARTS DURING THE LAST TEN YEARS.*

By Dr. A. W. Hofmann.†

[Continued from Vol. lxxi, page 67.]

It was subsequently, however, discovered‡ that at higher temperatures carbonic oxide is oxidized by watery vapor to carbonic acid, so that if the steam is in excess a gas may be obtained relatively free from carbonic oxide, as shown in the reaction—

$$C + {}_2H_2O = {}_4H + CO_2.$$

In the gas-water prepared at Narbonne, where the gas on issuing from the retorts is conducted through ignited tubes along with fresh quantities of superheated steam, Verver§ found in 1858, 3·54 per cent. of carbonic oxide. According to other observers the amount ranged from 2·5 to 5 per cent. In the water-gas at Passy, Payen found 6 per cent. of carbonic oxide, whilst in ordinary coal-gas he found an average of no less than 14 per cent. The above mentioned objection, therefore, no longer holds good.

The carbonic acid is removed by milk of lime, or, perhaps, more economically, according to the suggestion of Heurtebise‖ by soda, which is thereby converted into bicarbonate, a readily saleable substance.

Fayes¶ constructed for lighting the town of Narbonne an apparatus which he named gazogen, which furnished in twenty-four hours 1000 to 1200 cubic meters of purified gas, the cost of which, inde

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* "Berichte über die Entwickelung der Chemischen Industrie Während des Letzten Jahrzehends."

† From the *Chemical News.*

‡ Bromeis, *Zeitsch. d. Ver. deutsch. Ing.*, iii. 82, and *Dingler Polyt. J.*, clxiv. 33, 1895.

§ B. Verver. "L'éclassage au gaz à l'eau à Narbonne et L'èclairage au gaz Leprince." Leiden, 1858. See Bromeis, *opus citat.*

‖ Heurtebise *Dingl. Pol. J.*, cxxevi. (?) 393, 1867.

¶ Fayes, *Génie industriel*, 1868, 329. *Dingl. Pol. J.*, clix. 47.

pendent of labor, and of the cost and depreciation of plant, he calculates as follows:—

Per 100 *Cubic Meters of Gas.*

			f.	c.
75 kilometers	of coke	at 0·03 franc	2	25
55 "	coal	at 0·025 "	1	37
82 "	lime			82
			4	44

The material costs, therefore, 4½ centimes per cubic meter.

Instead of decomposing water by carbon, certain other processes have recently come into use, and require notice.

Lenoir's process,* suggested in 1867, is of very limited applicability. He decomposed barium sulphide with water, containing sulphate of baryta and hydrogen—

$$BaS + {}_4H_2O = BaSO_4 + {}_4H_2.$$

This process is only practicable where the manufacture of barium sulphate (permanent white) is the main object and the hydrogen a by-product, as was the case with Lenoir.

Tessié du Motay and Maréchal† have introduced a valuable modification into practice, as they require no steam-boiler for the manufacture of the water-gas, and thus economize fuel, whilst the wear of the simplified apparatus is considerably reduced. They heat coal with soda, hydrate of lime or of baryta in iron retorts, and thus decompose the combined water of these bases, which is then freed from carbonic acid in the ordinary manner. This procedure has been adopted by the New York Oxygen Company, who, in the manner described above, sell water-gas at the enormous price of 2 cents per cubic foot, or 1 cubic meter for 3s. 6d.‡ The mixture of lime and anthracite is heated in retorts such as those described above under Tessié du Motay's method of preparing oxygen. The decomposition takes place at a red-heat, according to the equation—

$$C + CaO + CH_2O = CaCO_3 + {}_2H_2,$$

and lasts about fifteen minutes. Thereupon hydrate of lime is reformed by passing steam over the heated mass. The carbon is not ex-

* Lenoir, *Wagn. Jahresber.*, 1867, 219, 259.

† *Bull. Soc Chim.*, 1868, i, 334.

‡ H. Vogel, *Ber. Chem. Ges.*, iii, 901.

hausted until after three weeks, and is then replaced by a fresh supply of anthracite.

That coal-gas contains large quantities (30 to 50 per cent.) of free hydrogen, and that the proportion of this ingredient rises the higher the temperature of the retorts in preparing the gas, has long been known. Tessié du Motay and Maréchal, whilst introducing the above-described procedure, have taken advantage of this circumstance, and have passed coal-gas over lime in order to resolve it into carbon, hydrocarbons boiling at high temperatures, and large quantities of hydrogen. At the same time E. Vial* adopted the same method, and has doubled, and even trebled the yield of gas by "decarburation." Schinz† doubts the industrial value of this process, on account of the outlay for fuel, and calculates that the decomposition of water by means of coal yields a luminous gas for half the cost of coal-gas. Here, however, as we shall presently see, the depreciation of the plant has not been taken into account.

If we now inquire in what manner the hydrogen, however obtained is rendered luminous, we find two essentially different methods. The one depends on mixing the water-gas with hydrocarbons. As early as 1834‡ Selligue employed, at Paris, the oils obtained by distilling the marl-shales of Autun in order to saturate the water-gas with gaseous hydrocarbons. White subsequently passed the water-gas through retorts in which rosin or coal was converted into luminous gas, and its process was carefully examined in 1851 by Frankland,§ who concludes a laudatory report with certain propositions, of which the following are the most important:—

1. The production of gas from given weights of common coal or of cannel is increased by 46 to 290 per cent. according to the quality of the material employed.

2. The luminous power is increased by 12 to 108 per cent. the more when coals are employed which produce gas of a highly luminous power.

3. The quality of the residual tar is lowered, a part of it being converted into gas of a strong luminous power.

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* Vial, *Genie Industriel*, 1869. *Dingl. Pol. J.*, cli, 382.

† Schinz, *Dingl. Pol. J.*, cii, 388.

‡ Dumas, "Handbuch der Chemie," vii.

§ Frankland, *Ann. Chem. Pharm.* lxxxii, 48.

It must be remarked that tar had not at that time the value which it has subsequently reached.

White's process recurs, with trifling modifications under a variety of names.

As the "système Leprince," or "gas mixture Leprince," it was introduced into industrial concerns at Liege, adopted by the town of Mastricht, and by some departments of the Vieille Montagne at Verviers, and was critically described by Verver in 1848 in his work above quoted. Four years afterwards a similar procedure was elaborated by Baldanus and Grüne,* for which Schaffer and Walcker obtained a patent in Prussia. Their process consisted in passing steam through retorts in which coal-shales, turf, and other combustibles were heated to redness. It differs, therefore, from White's process herein that the production of hydrogen and its carburation are effected in the same retort. An ordinary gas retort 8½ feet in length is said to yield, in twenty-four hours, 8000 to 9000 cubic feet of this gas; and in Wagemann's manufactory at Benel, near Bonn, where this process has been introduced, 1 cwt. of coal-shale was consumed per 1000 cubic feet of gas.

Essentially different is the second method of employing hydrogen for lighting, as carried out in 1846 by Gillard, at Passy, near Paris. He fixed on the burners,† from which the water-gas issued, baskets of platinum wire, which, on the ignition of the gas, were heated to brilliant whiteness. Hence it was called platinum gas (*gaz platine*). The immobility of the light, even in a strong wind, the dispensing with lamp-glasses, which, according to Verver, absorb 22 per cent. of the light, and the brilliance obtained on this principle, must be considered as advantages, although the intensity is not free from objections. Its use was not continued at Passy, but it was introduced by the celebrated firm of Christofle & Co., into their electro-plating works at Paris,‡ and was employed to light the streets of Narbonne. The hourly consumption of gas being 3·234 cubic feet (=0·1 cubic meter), the light was equal to that of 5·22 normal candles, and, though the lamps at Narboone were placed at intervals of 50 meters, Verver pronounced the lighting of the streets as perfect.

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* *Journal für Gasbeleuchtung*, 1862, p. 63.

† Report by O. Henry, *Journ. Pharmacie* [3], xvii, 105; *Dingler's Journal*, cxvi, 222; and the Reports of Bromeis and Ververs.

‡ Wagner. "Handbuch der Technologie," 1873, ii, 371.

Latterly, since the preparation of hydrogen has been improved by Tessié du Motay and Maréchal, new attempts have been made in Paris to light up large squares and streets with "platinum gas." Spectators, however, may find justification for the caricatures in the Parisian comic journals of that time, which represent the passengers in the streets, and even infants in arms, and the very dogs in the gutters, equipped with eye-shades to preserve their sight.

Technical literature has the peculiarity that it records the introduction of novelties, but leaves us in the dark, concerning their practical verification. It keeps a tolerably exact register of the births of inventions, but gives a very imperfect account of their career in life, and of their deaths. Thus, with a single exception, we are left in the dark as to the permanent results of lighting with hydrogen.

The experiments made with water-gas at the town Elizabeth, in New Jersey, yielded unsatisfactory results, as made known in 1865.* Great depreciation of plant, heavy working expenses, and disproportionate consumption of fuel, were the causes of failure.

It was, therefore, the more desirable to ascertain in how far the process had proved successful in Europe, and, thanks to the kindness of several correspondents, we have succeeded in obtaining information. The fate of the method in Belgium, appears from an extract from a letter which M. L. de Koninck, Professor of Chemistry at the University of Liege, kindly forwarded to the present writer:—

The *systeme Leprince*, which consists in the introduction of small quantities of water into the retorts in which coal is distilled, had for a short time, a certain success (*une certaine vogue*), depending mainly on numerous reclamations by which it was helped out. Its chief advantage was supposed to lie in the fact that it drove the gas out of the retort, a purpose for which an exhauster or aspirator is now preferred. The system has never been employed for public purposes in Belgium, but merely in certain manufactories. Since the death of the inventor, which took place some years ago, it is no longer spoken of, and has been generally, if not universally abandoned. This has been the case at Vieille-Montagne.

In a letter dated March 18, 1874, M. Landolt, Professor of Chemistry at the Polytechnic School of Aachen, confirms these statements.

* Wagner, *Jahresberichte*, 1865, 758.

The use of water-gas is continued only in Cockerill's works at Seraing. At Simoni's cloth works at Verviers the process never advanced beyond the stage of unsatisfactory experiments, although certain technological papers have asserted to the contrary. In Maestricht where the water-gas was used for some time for public purposes, it has, as Professor Landolt has been informed, failed to give lasting satisfaction, and has been replaced by coal gas two years ago (1872). Direct inquiries addressed to the municipal authorities have remained unanswered.

The above statement of the introduction of the Drummond light in English military establishments led to an inquiry being addressed to the Chemist to the War Department, Mr. Abel, of Woolwich, from whom the following courteous reply was received, under date April 20, 1874: "As regards your inquiry concerning the introduction of the lime-light in military premises, I have to communicate that at the period you mention experiments were made for a short time in two of our establishments, but that the question of its formal introduction has never been seriously entertained."

The illumination of the galvano-plastic works of Christofle with water-gas was likewise of brief duration, and the process has been long ago abandoned. We are indebted to this firm for the following communication under date April 21, 1874: "In reply to your letter of the 17th, we have to state that the use of hydrogen in our works came to an end in 1853, on account of certain difficulties (*inconvenients*) which presented themselves, and that we have no longer preserved the documents bearing upon the matter."

It only remained to ascertain the fate of the so-called platinum gas at Narbonne. To do this with certainty there appeared no other method than to appeal to the courtesy of the municipal authorities. The Mayor of Narbonne had the kindness to comply fully with our request, and to sign the following instructive and characteristic letter, dated March 16: "The relations of Prussia and France since the war impose upon me the greatest caution as regards inquiries. As the question, however, is one of a purely scientific nature, I have handed over your letter to the Abbé Prax, chemist to the Agricultural Society of Narbonne, who has for a long time occupied himself with the subject. I have the honor to enclose a copy of the memoir which he placed in my hands."

ACCOUNT OF THE WATER-GAS IN NARBONNE FROM 1855 TO 1865.

"In May, 1855, I was sent to Paris by the municipality to test the water-gas of Passy. My report was dated June 8, 1855. The town adopted this method of lighting and heating and came to an agreement with the company called the 'Narbonnaise.'

"From 1856 the Passy system was in use in Narbonne. We modified the burners in several respects, as those of Passy were not sufficiently lasting. The high temperature of the retorts occasioned from time to time the loss of a furnace, and after many losses the system of retorts was abandoned in favor of another apparatus, the 'Cubilot,' (Faye's apparatus). Towards the end of 1858, it was heated with wood charcoal, which soon gave place to coke, on account of its costliness. At the same time we made important changes in the burners and platinum baskets, the latter of which were suspended instead of resting upon the former.

"The illumination with hydrogen is brilliant but sensitive (*délicat*). The lamps in the streets must be well closed, as a gust of wind distorts the ignited platinum wick. The dust introduces sand, which forms a silicide of platinum, and this metal ultimately assumes an injurious crystalline structure and is even partially volatilized.

"In Narbonne all care was wanting towards the end of the career of the company Narbonnaise. The manager, M. Crouzet, became a wine merchant in Paris. All superintendence was withheld, and the lighting became at last intolerable. In June, 1865, therefore, coal gas was introduced. As far as heating is concerned, nothing can in my opinion compete with water-gas in convenience and cheapness.

"PRAX,

"Narbonne, March 15, 1874. "*Chemist to the Agricultural Society.*"

Ballooning had been made subservient to the purposes of meteorology and physics before it was enlisted in the service of the war-spirit. Charles utilized his expedition for scientific purposes. On July 18th, 1803, he was imitated by Robertson, who ascended from Hamburg to the height of 7400 meters, and who imagined that he perceived at this altitude a decrease in the intensity, not merely of terrestrial magnetism, but also of frictional electricity. These statements induced the great physicists, Biot and Gay-Lussac, to undertake two ascents the next year. They refuted the above mentioned views of Robertson, remarked the decrease of atmospheric moisture with

increasing altitude, and made numerous and valuable meteorological observations. From the greatest height which they attained, 6500 meters, Gay-Lussac brought back a specimen of air, and found that it had the same composition as the air of lower regions—a result at that time, of capital importance. The last mentioned ascents were all made with hydrogen gas. As the use of gas-lighting became more and more general, the greater power which the lightest of all known bodies offers was sacrificed to the convenience which coal-gas afforded. In France, Barral and Bixio made their scientific ascent in 1850 with the aid of coal-gas. In England, Glaisher adopted the same plan in 1864; and the numerous balloon voyages which have been made for the amusement of the public, from the love of adventure, or for some especial purpose, have been undertaken with the same material. With coal-gas, Green traveled in sixteen hours, from London to Weilburg, in Nassau, in 1836; Flammarion and Godard in 1867, from Paris to Solingen, performing 70 German miles in twelve and a half hours. Nader, who hoped to take photographic maps whilst floating in the air, had filled his balloon "Le Géant," with 6000 cubic meters of coal-gas, on his somewhat dangerous journey from Paris to Hanover, October 18th, 1863. More recently aeronauts have returned to the use of hydrogen. But even in those four months of the greatest siege of a metropolis of which history bears record, when Paris depended exclusively for its intercourse with the outer world upon carrier pigeons and balloons, which had never before been called to so important a service, even then necessity compelled the use of coal-gas, because it was procurable with the least difficulty.* 65 balloons went up from Paris between September 28th and January 22d, carrying 91 passengers, 363 pigeons, and 2½ million letters, and for the most part with success. Only five balloons fell into the hands of the German armies; one descended in Munich, another at Wetzlar, one disappeared entirely, perhaps in the sea, whilst the fragments of another were found in the autumn of 1873 clinging to a tree at Port Natal, in southeastern Africa. All the others descended safely beyond the radius of the besieging army in France or upon neutral territory; one in Belgium, three in Holland, and one upon a snow-field in Norway, sixty (German) miles to

* Saint-Edme, "La Science pendant le Siége de Paris," 1871, 62.

the north of Christiana, and one hundred and eighty from Paris, which had been traversed in fifteen hours.*

At that time, the power of steering balloons was more than ever felt to be necessary. Many of Montgolfier's contemporaries, including well-known physicists and mathematicians such as Meusnier, Monge, Lalande, etc., had pronounced this problem to be practicable. Fruitless and partially absurd attempts at its solution were not wanting. The celebrated inventor of the injector, Henry Giffard, was not deterred from carrying out new experiments in this direction, in the year 1852, and the most recent attempts are based upon his ideas and those of Meusnier. Instead of the ordinary form, Giffard gave his balloon the fish-like shape of a ship, for the convenience of steering. A steam engine, with its chimney turned downwards, to obviate the risk of fire, and whose steam was simultaneously employed to maintain the draught, turned a screw sufficient to turn the balloon, but certainly too weak to overcome the strong wind, which, on September 25th, drove Giffard's aerial ship before it. Public opinion then turned in favor of a project of aerial navigation opposed to all previous methods. Ponton d'Amecourt, De la Landell, and Nadar, wished to attempt by mere mechanical force, without the aid of light gases, to navigate the air in all directions. The authority of Babinet suppported this scheme, which, however, according to Helmholtz,† had no sound physical basis, and which, when carried into execution, proved a failure.

When the Paris Exhibition of 1867 drew general attention to every industrial advance, Giffard received a commission to make aeronautics available for the "million" by means of a hydrogen balloon. He constructed a balloon of 5000 cubic meters capacity, the inflation of which, with hydrogen generated by iron and sulphuric acid in wooden casks, cost 5000 francs. The gas was subsequently prepared by him for a twentieth part of the cost of conducting steam over ignited charcoal, a method of which Coutelle had made use in 1794. The balloon was attached to a wire rope, 300 meters in length, and was very skilfully secured. A steam engine of 50 horse power uncoiled the rope, and drew down the balloon with its passengers, when the

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* Stephan, *Weltpost und Luftschiffahrt.* Berlin, 1874.

† Helmholtz, *Berl. Akad. Ber. u. Verhand d. Ver. für Gewerbfleiss in Preussen*, 1873, 326.

permitted height had been reached. This height was not great enough to occasion any danger from the expansion of the gas; hence Giffard was able to close the balloon with valves instead of leaving it open below. Thus, the loss of gas by diffusion did not exceed 15 cubic meters daily, and was easily replaced at intervals of three days.

The next impulse to aeronautics was given, not by festivity, but by the terrors of war and the siege of Paris. The Académie des Sciences commissioned one of its members, Dupuy de Lôme, to make experiments on steering balloons, and the government furnished the requisite means. Dupuy gave his balloon the fish shape,* and in order to render its shape stable in the wind, he fitted it with an internal secondary balloon (*ballonet*), containing more or less air, and equal in bulk to one-tenth part of the main balloon. The air could be let out of this inner balloon by valves, or driven in again by means of a bellows in the car, according to a plan which Meusnier had devised as early as 1783, to supersede the use of ballast. Dupuy's balloon was further distinguished by a very firm method of suspending the car, and by the use of a varnish impermeable to gases, and made of gelatine and tannin dissolved in pyroligneous acid. The propelling screw was not turned by a steam engine, but by eight men in the car. The balloon, containing 3450 cubic meters, was filled with hydrogen obtained from iron and suphuric acid, and went up at Vincennes, on February 1st, 1872, carrying fourteen persons. After a flight of two hours, it was let down at Noyon, a distance of 106 kilometers. By means of an anemometer, Dupuy was able to determine the independent speed of the balloon at 2·82 meters per second, whilst that of the wind was 16 to 17 meters, and the course of the balloon made an angle of 12° with the direction of the wind. The problem of steering had, therefore, been solved, though only to a very slight degree—sufficient for a calm, but insufficient for overcoming even moderate winds. The speed attained was slight. Both conditions of success depend on the employment of stronger sources of mechanical power, and this, again, requires an increase of its power of ascent, *i. e.*, of its relative levity with an enlarged volume.

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* Dupuy de Lome, "Note sur l'Aerostat." Paris: Gautier-Villars, 1872.

(To be continued.)

ON FORMATION OF CLOUD IN RAREFIED MOIST AIR.*

When a given quantity of air, saturated with water-vapor, is suddenly rarefied, a part of this vapor (it is known) is precipated as cloud, in consequence of the fall of temperature. In a paper recently contributed to the *Journal de Pharmacie et de Chemie*, M. Conlier states that to render this phenomenon more apparent he procured a large zinc tube 3 meters in length, and closed the ends of it with glass discs. He introduced a little water, compressed the air present, for a little, and then opened a cock at the side, so relieving the compression. Thereupon appeared a pretty thick cloud, through which the outline of a candle-flame could not be perceived. Having, after some days, however, repeated the experiment, he found that it did not always succeed; and he set himself to find the reason of this.

With this view, he obtained a three-necked flask, the bottom of which was covered with water. Two of the necks were furnished with cocks, while the third was connected by a caoutchouc tube with a balloon of caoutchouc, the compression of which, when both cocks were closed, produced an instant compression of the air in the flask; on removing the pressure, the air expanded again, and a cloud was formed in the flask. The cloud spherules thus produced were of various sizes, and were in constant motion. On looking at a flame through the cloud, one observed the well-known colored rings.

Hitherto the formation of these clouds has been explained by precipitation of water in consequence of cooling. The following experiment shows, however, that this explanation is not exact. If the flask is allowed to stand some time undisturbed, the phenomenon is not obtained. Under circumstances that are apparently exactly the same as those of the experiment at first, the air remains perfectly clear. To explain this fact it must be supposed that this air has been altered in composition, and has lost a constituent, which gave it the property of becoming troubled in expansion. This element seems to be soluble in water; for if you vigorously shake the flask when it contains the cloud-giving air, the air becomes inoperative.

Carbonic acid, oxygen, and various other gases, are without influence on the phenomenon. In the water at the bottom of the flask no new constituent could be discovered. If it be wished to repeat

* From *English Mechanic*, London, December 17th, 1875.

the experiment with a flask that has become inoperative, there is nothing for it but to remove the inclosed air, and substitute external air. Thereafter the cloud is readily obtained. M. Conlier now conceived the idea of filtering the air before it entered the flask; an operation easily effected by first squeezing the balloon, and so forcing out a portion of the air, and then placing before the cock, through which air must again enter, a plug of cotton wool. The air thus admitted was found to be *inoperative*. The filtering had taken away from it the power of giving a cloud.

This remarkable action of the filter had led to the hypothesis that the air contained certain fine, solid particles, which occasioned the formation of cloud. These particles were held back by the filter. In the case of the vessel remaining several days at rest, they fall to the bottom, and remain in the water. And in a similar way, shaking the flask makes the air inoperative. When the air is completely free from these floating particles, a slight expansion produces no cloud; the air rather remains in a measure super-saturated. When, on the other hand, a solid particle floats in the air, this causes the liquefaction of the vapor; it acts like a nucleus for the water-vesicle, or droplet, and the cloud is immediately formed. This explanation became the starting-point for further confirmatory experiments.

If a small quantity of tobacco or other smoke be brought into the flask—so small that it does not perceptibly trouble the air of the flask, it makes it uncommonly sensitive.

On the other hand, to render inoperative the dust which brings about the formation of cloud, it might previously be burnt. For this purpose, the air before being admitted to the flask was strongly heated in an unsooty alcohol flame; but, contrary to expectation, the air so treated proved even more operative than ordinary air. The reason of this soon appeared in the fact that the air passing through the flame took up carbon particles, which served as nuclei for the cloud formation. Mr. Conlier, indeed, found that even the quite unsooty flames give gases, which, on being filtered through cotton wool, color the parts of this that are first encountered black, or at least gray; indicating that they contain fine particles of carbon.

An estimation of the amount of carbon dust which could make the air in the flask operative, gave the value of $\frac{1}{14400}$ milligram.

M. Conlier inclines to the belief that the carbon particles which are always mixed with the normal Paris air, are in general the op-

erative cause in the phenomenon of cloud formation; and he utilizes the greater or less formation of cloud, in a flask like the one described, as a rough scale of measurement for the quantity of dust in the air.

From numerous and repeated experiments he found that the external air is never wholly inoperative. Great differences could be perceived, however, the cloud obtained was more or less stable; it disappeared, in many cases faster than in others. A pretty continuous rain and snow appeared to hinder the cloud formation; so did bad weather with strong winds; a moderate amount of cloud seemed not to increase the activity of the air. In summer of this year, the air was somewhat less operative than in winter, 1874.

M. Muscart, who has repeated these experiments, finds that other liquids besides water, viz.: alcohol, benzine, etc., give similar actions He finds strongly ozonized air very operative, and in this case the cotton wool filter was not capable of robbing the air of its activity. "This action of ozonized air," he says, "cannot be explained by the experiments adduced; it proves that various circumstances may make the air active, and that this activity, though mostly depending on the mechanical action of particles floating in the air, can also be called forth by other causes."

MEANS OF DISTINGUISHING FERMENTS.

Abstract, by C. B. Dudley, Ph. D.

In the July number of *Annales de Chimie et de Physique*, M. A. Müntz, gives some interesting statements in reference to ferments. Assuming that fermentation is caused by two different kinds of ferments, viz.: (1). Minute organisms endowed with life, and (2). Unorganized nitrogenous substances; he gives a means of distinguishing between these. According to his statement, fermentation, which takes place as the result of the presence of minute living organisms, is completely and entirely prevented by the addition of a few drops of chloroform, while the same substance has absolutely no influence upon the action of the unorganized nitrogenous ferments. As a proof of this, ten different experiments are cited, five to establish the first point, and five the second.

(1). Five cubic centimeters of chloroform were added to 200 c. c. of milk. The liquid remained four months without thickening, and no organisms showed themselves.

(2). Two hundred c. c. of fresh urine with 2 c. c. of chloroform, remained two months at a temperature from 25° C. to 30° C., without undergoing ammoniacal fermentation, and as before, no organisms appeared.

(3). Ten grains of cane sugar, dissolved in 200 c. c. of water, in presence of chalk, cheese, and of 3 c. c. of chloroform, did not show lactic fermentation at the end of four months, and again no organisms took birth in the liquid.

(4). Flesh, gelatine, starch and other similar substances, in presence of water and a small quantity of chloroform, remained for three months without change, in spite of a temperature of about 30° C, to which they were submitted. No living being, either animal or vegetable, could be found in the liquid.

(5). The alcoholic fermentation of sugar, in presence of brewer's yeast, is completely arrested from the moment when chloroform is placed in the liquid.

To show that chloroform has no influence whatever upon the nitrogenous ferments, the following experiments are given:

(1). Two grains of dry, sprouted barley, containing originally 50 milligrams of glucose, were put into 40 c. c. of water and 5 c. c. of chloroform. At the end of 50 hours, 520 milligrams of glucose had been formed. In a parallel experiment, without chloroform, 540 milligrams of glucose were developed in the same time.

(2). Ten grains of oil-cake of bitter almonds, containing originally 6 milligrams of Prussic acid, were placed in 300 c. c. of water and 5 c. c. of chloroform. At the end of 70 hours 32 milligrams of Prussic acid had been formed. In a parallel experiment, without chloroform, 32 milligrams of Prussic acid were formed.

(3). A solution of starch, containing originally in 100 c. c. 15 milligrams of glucose, was placed in contact with saliva and chloroform in large quantity. After 15 hours, 100 c. c. of the solution contained 120 milligrams of glucose. One hundred c. c. of the same starch solution, treated with saliva, but without chloroform, yielded in the same time, 110 milligrams of glucose.

(4). Some mustard seed flour, which contained only traces of vola-

tile oil, placed in contact with water and chloroform, developed as strong an odor as that from the flour treated with water alone.

(5). One hundred c. c. of a solution of cane sugar, containing 5 per cent. of sugar, showed in a saccharineter 33° to the right. Three grains of yeast and five drops of chloroform were added. Not a bubble of carbonic acid was disengaged, and yet, at the end of 48 hours, the liquid showed in the saccharineter 9·5° to the left. In this experiment the yeast produced its chemical action, viz., inversion; but alcoholic fermentation did not follow.

If these experiments are to be relied on, Pasteur's theory that all fermentation is the result of the action of living organisms, would still seem to need confirmation.

A CURIOUS CASE OF MAGNETIZATION.*

By M. J. Jamin.

A bar of steel may be magnetized to saturation by a very powerful current, and to one of the halves may be given a southern magnetization, which I shall call *positive*, and which extends to the very centre or heart of the bar. This being done, I submit the bar to a current in the reverse direction, weak at first, but gradually increasing, which produces a northern or *negative* magnetization, limited at first to the surface but penetrating afterwards to an increasing depth, always leaving, however, layers of positive polarity underneath. The effect observed is but the result of the difference of action of the two magnetizations superposed one over the other, as manifested externally. It is first positive, then neutral, and finally negative. I stop directly the change of sign is apparent.

I afterwards dissolve the steel in acid, and it is evident that I thus remove little by little, the exterior northern or negative layers, and expose the underlying southern ones; that the magnetization observed is at first negative, then diminishes, becomes neutral, and then changes the sign.

I have now to add that the southern layers are not laid bare throughout at the same time. They commence to show themselves at the end, and especially at the edges and corners as points, very sharp, and of

* From the *Comptes Rendus* of the Academy of Sciences, Paris.

very small extent. They have then a great tension, but their magnetic momentum is small, because they occupy a very small surface. At the same time there exists a northern layer extending uninterruptedly from the end to the mean line; this is the remainder of the exterior layers which have not yet been eaten away by the acid. The intensity of the latter is almost nil at any given point, but the surface being large the quantity and momentum of this northern magnetism are considerable, more considerable than the quantity and momentum of the southern points which protrude at the very end; it follows that this half of the bar turns to the south as if these last mentioned points did not exist.

Let us bring forward gradually the southern pole of an ordinary magnet; whilst it is at some distance, it is subject to the predominant influence of the northern layers of our bar, and is attracted, but if it is brought to the end of the bar, it comes very near to the southern points, which are situated at the end, the force of the latter prevails, and repulsion takes place; thus we have attraction at a distance and repulsion upon contact; and, what is no less curious, upon contact, repulsion of the extremities which turn to the contrary poles of the earth, and attraction of the extremities which turn to the same side. At a sufficient distance, the direction of the effects changes, and everything takes place in the accustomed order.

HOW TO EXTEND THE CAPABILITIES OF A LANDSCAPE AND COPYING LENS.*

There are few photographers who do not frequently feel the necessity for a far greater elasticity, so to speak, in the apparatus employed by them when out afield in the prosecution of their pictorial labors. This elasticity, or increase of accommodation and power, is especially desirable in respect to the lens employed; for circumstances very often arise which cause a lens suitable for the general course of work to become unsuitable on special occasions.

To meet the exigencies which thus so often arise, landscape photographers now rarely go from home without more than one lens; for it is obvious that, if the object to be photographed appear too small and insignificant upon the ground glass when using a lens of a certain focal length, two ways only remain by which this dwarfed appearance

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* From the *British Journal of Photography*, Nov. 12th, 1875.

can be remedied, namely, either by going much nearer to the object in question, or by substituting a lens of much longer focus for that by which the image was projected upon the ground glass. The former is often artistically impossible when once the view has been carefully composed and selected; for the perfection of the picture may depend upon the relation certain portions of the scene—such as rocks, trees, or foreground objects—bear to the main object, and the alteration of the point of view might be entirely subversive of such harmonious composition. The latter implies the possession of such a variety of lenses as will meet cases of difficulty of this kind as they occur. By far the best plan is for the tourist photographer to travel with lenses of various foci; for he can, under such circumstances, select his view with the greatest care without regard to the general capabilities of the lens, which he will then select from his stock with special reference to its peculiar attributes for accomplishing the work laid out for it by the photographer.

While such is the best mode of securing the object in view, it is, however, one in which the amateur of moderate means dare not freely indulge, on account of the large expenditure involved. It is our object here to indicate in what way the possessor of one good lens may be able to utilize it for divers kinds of work, by varying its focus within a considerable range, and thus producing a small, large, or medium sized picture at will.

It is well known that any of the cemented, non-distorting combinations now so much used may also be employed in the single form; that is, the back or front lens of such a combination may be used alone. In this condition it is double the focal length of the complete combination, and covers a plate of twice the dimensions capable of being covered by the other; but when employed in this way it is not adapted, when worked up to its full covering power, for architectural subjects, owing to its curving the straight lines of the building delineated near the margin of the picture. When, however, skill is exercised this kind of curvature is not noticeable—a fact amply proved in a very large and excellent picture of *Kirkstall Abbey* we recently received from Mr. Wormald, of Leeds, in which, owing to his not having an objective of sufficient focal length, the posterior element of one of his combinations was pressed into service.

We shall now show by what means the focus of such combinations may be varied to a great extent without introducing any linear dis-

tortion; but before doing so we must remind the reader that the correction of a photographic lens is only a compromise, some inactive rays being brought to a focus along with those of most activity, although some of the latter class are left outstanding. We shall take as the lens on which the following experiments and remarks are based one of those now so well known respectively as the "rectilinear," the "symmetrical" and the "Steinheil aplanatic," this particular class of instrument being most rapid in action. When a lens of this order is used in its complete form—that is, as sent from the maker—it covers a plate of certain dimensions without any diaphragm; but by using a small stop the covering power is extended and the area of sharp definition increased. If now a series of very weak concave lenses be obtained (those by means of which we have conducted a large number of experiments were spectacle lenses for short sights), and if one of these be inserted midway between the lenses of the photographic combination, the focus, and, consequently, the covering power, will be greatly increased. To give an instance: we possess a lens coming under the category above named, purported by the maker to cover a 6 × 5-inch plate. In total disregard of its maker's suggestion, we have invariably used it for plates 7½ × 5; and when employed with a small stop the back lens alone will cover 12 × 10—with, of course, a curvilinear distortion when applied to architecture on a plate of such dimensions. With a view to converting it temporarily into a 12 × 10 *non-distorting* instrument, we selected a concave lens of the cheap class already indicated—the strength of this lens being such as nearly to neutralize one of the achromatics of the combination—and inserted it in the position of the diaphragm. The effect was that the focus of the combination was immediately doubled, with absolute freedom from distortion. When taking a picture with it in this altered condition, we found it necessary to use a small stop, as the field was now over-corrected for flatness; but what we scarcely expected to find was the fact of the lens working to visual focus—a fact at which one's wonder ceases when it is considered that, as we have already said, photographic correction of color is a compromise.

From the foregoing, and from several other experiments of which that given is a type, we draw the conclusion that a photographer with only one lens may greatly extend its capabilities at a small cost by having its mount so altered—presuming Waterhouse stops are used—as to render it possible to drop in one of a series of diaphragms made

as follows:—Provide three or four of the weakest concave spectacle lenses produced, but of progressive strength, and chip them down to about the dimensions of a shilling. When of this diameter they will be very thin. Next attach each of these little lenses to a brass stop of the ordinary Waterhouse form, adopting such means as will be suggested to any one possessing a mechanical turn of mind—the best in our estimation consisting in soldering upon the stop a very shallow ring of brass sawn from the end of a tube, the depth being such as to leave it on a level with the edge of the lens. A series of these lenses thus fitted ready for insertion can be carried in a diaphragm pocket-case having divisions to prevent them coming into contact one with the other; and, after the value of each, as respects the additional lengthening of the focus of the combination, has been engraved or scratched on the brass portion of the stop, a photographer who goes to the country with such an adjunct to his lens will find himself enabled to secure effects which without such assistance would be impossible, while, at the same time, the good qualities of the lens as it issued from the hands of its maker are still preserved intact.

What has been said as regards the lengthening of the focus by means of a *concave* lens applies equally to the shortening of it by the expedient of using one of a convex form.

A FEW INSTANCES, SHOWING THE POSSIBILITY OF APPLYING THE MICROSCOPE TO INORGANIC, QUALITATIVE ANALYSIS. A THESIS.

By Frank W. Very.

Preface.—The researches narrated in this paper, have been limited by the low power of the microscope used, and by the shortness of the time which could be given to such work. The first cause has obliged us to throw aside many precipitates (often most delicate tests for the substance under consideration), which could perhaps be made available by means of higher magnifying power.

It is the author's opinion, that a method can be devised for carrying on a complete qualitative analysis by means of the microscope,

with the use of appropriate reagents; but to discover the tests, which are best fitted for the purpose, and which give the most distinctive crystals, under conditions that may be defined, is a labor of years.

Such a method would be of especial use where only a limited quantity of a substance could be obtained, as in the case of rare minerals, a single small crystal would be sufficient for an analysis. Or it might become of use in the examination of the residue left by the evaporation of mineral water.

In its present state, the method does not seem to be as delicate as the ordinary one; perhaps it can never be made so. The matter which causes a perceptible cloudiness in a large mass of liquid, may be so finely divided, that the microscope would fail to recognize the form of the particles. On the other hand, the microscope will probably have the advantage of rapidity in the prosecution of the work. In many cases it will enable us to recognize one or more elements in the presence of others, which in the ordinary method would have to be removed first.

The few tests which are herein described, can hardly be called very successful. There are doubtless much better ones to be discovered. They will serve, however, as a basis for further investigation, and the general considerations deduced from them will always be of use.

General Directions.—It would be best to use an inverted microscope for these researches, because strong acids could then be applied as reagents without injury to the objective from their fumes. In this case, thin glass slides must be used. These can best be made by cutting a hole in an ordinary slide, over which a piece of thin glass is cemented.

Small test-tubes or phials, two or three inches long, are convenient for holding reagents and the solutions to be tested. A drop of the liquid may be removed from these by means of a glass rod; or if more of the liquid be needed, a pipette, made of a capillary tube, may be used. In either case, the utensil should be washed at once, and a basin of water should be kept at hand for this purpose, and for washing the slides.

There ought to be several tests for each element, to act as checks, and we can the better afford this since a single test often shows two or three elements at once.

When precipitations are in order, it is a safe rule to have the solutions tolerably dilute, provided the precipitate is sufficiently insoluble. The precise amount of dilution must be determined for each case by experiment. Unless this be done, the crystals come in such confused masses that they are hard to distinguish. Extremely insoluble precipitates are generally very finely divided. Here dilution is absolutely essential, if recognizable crystals are to be obtained. Even very great dilution does not always succeed in bringing this about. In dilute solutions it is often necessary to wait a while for the crystals to form; and, in very many solutions, the formation of crystals is facilitated by agitating the liquid with a stirring rod. As the latter scrapes against the glass slide, the crystals fall in its track in thickly set rows. The crystals produced in this way are generally smaller than they would otherwise be, but are more perfectly formed.

In the production of crystals by evaporation, the liquid must necessarily be concentrated; and the serried, interlacing forms produced in this manner are often difficult to recognize, especially as they are apt to vary considerably. Hence precipitations are generally more desirable than evaporations. However, some substances can be readily recognized from evaporated preparations, particularly if the same conditions of temperature, and so forth, are used in every case; but there is generally an element of uncertainty, because the other substances, which may be in solution, are apt to influence the form of the crystalline aggregation.

Some solutions evaporate well enough spontaneously, but generally a slight degree of heat is necessary. If the heat is applied merely to concentrate the liquid, it need not be noted; otherwise the thermometer should be consulted. Very good results may be obtained, even with deliquescent substances, by evaporating under the receiver of an air-pump, over sulphuric acid; but this is a rather slow operation. To prevent the crystals from interlacing too thickly, the slide may be canted a little, so as to leave a very thin layer of liquid on the upper edge of the drop. Evaporation will here go on very rapidly, and the crystals will be farther apart.

The precipitation of a substance may often be effected by the addition of a liquid, in which it is much less soluble, provided the solution is already sufficiently concentrated. Several examples of this

will be mentioned. The common solvents, water, alcohol and ether, will be the ones most used in this way.

In evaporation, as well as in precipitation, the crystals should be watched from the commencement of their formation, as they are then more distinct, and afterwards become too much intermingled.

There is undoubtedly a general family resemblance between the various dentritic forms in which the same substance is wont to crystallize under slightly different conditions or on different occasions; but it is very hard to analyze these resemblances, and to state wherein they consist.

The same saline solution, evaporated under the same conditions of temperature, will give crystalline forms which vary remarkably. The multifarious shapes which snow-flakes take, are well known. Perhaps, if we were as well acquainted with other substances, we should find a similar diversity; although water is such a wonderful substance in many other respects, that it would not be surprising if it should surpass all others in the variety of its crystalline forms. It would be interesting to note the variation of a single substance (as $Ba\ Cl_2$, for example), when evaporated under different conditions of temperature, pressure and atmospheric humidity. Perhaps the passage of an electric current would influence the phenomenon.

The deposition of metals upon the passage of an electric current through their solutions, is well observed under the microscope. The crystallizations generally take the form of trees, like those produced when similar experiments are tried on a larger scale, as in the formation of the well known lead and silver trees.

To obtain these metallic crystals, two strips of platinum foil are fastened to the upper surface of the slide with shellac, leaving a distance of three or four millimeters between their free ends. The other ends of the platinum strips communicate with the poles of a battery. The drop of liquid being placed on the slide, so as to connect the platinum terminals, the metallic tree begins to advance slowly from one of these, moving faster, however, as it approaches the opposite electrode; because the resistance to the current becomes less as the distance which it has to travel lessens.

There is a decided difference between the crystallizations of the various metals, yet it would be difficult to recognize them if mixed together; because the differences, though decided, and quite con-

Fig. 1.
× 25

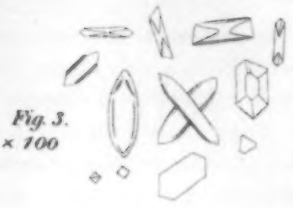

Fig. 3.
× 100

Fig. 4.
× 25

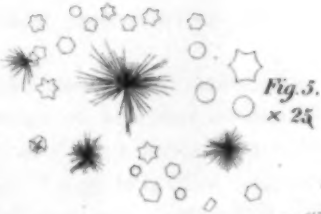

Fig. 5.
× 25

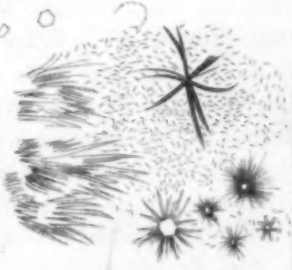

Fig. 6.
× 25

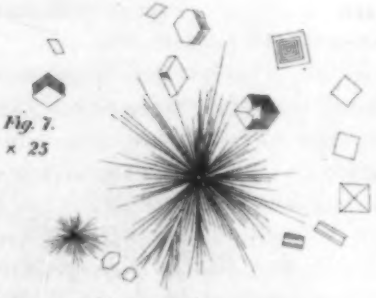

Fig. 7.
× 25

Fig. 8.
× 25

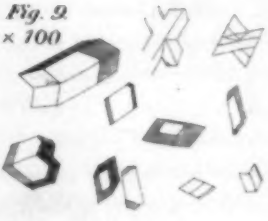

Fig. 9.
× 100

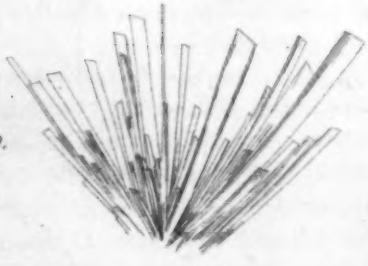

Fig. 10.
× 25

Lith. Lemercier & Co.

stant, are very slight, and it is hard to recollect the precise degree of complexity of the interlacing feathery fibers.

SPECIAL CASES.—Scheme for detecting Lead, Bismuth, Copper and Cadmium, in presence of each other:

Precipitate the metals as carbonates with sodic carbonate. Wash the precipitate.

I. Dissolve a portion of the mixed carbonates in nitric acid. (N. B. The concentrated reagents are always meant, unless otherwise stated.) If much lead is present, a portion of plumbic nitrate will remain undissolved.

a. To one drop of the liquid add water. The basic nitrate of bismuth will be precipitated in beautiful radiate bunches of plates (Fig. 1, Plate I), which are easily recognized. When the water is added, there is first a very fine precipitate, in the midst of which the radiating bunches appear, and increase in size while the first precipitate disappears.

b. To another drop of the solution add alcohol. Dendritic crosses, formed by three bars intersecting at right-angles, will be formed, (Fig. 2, Plate II). Plumbic nitrate is precipitated in this manner by alcohol.

II. Dissolve a portion of the carbonates in chlorhydric acid. If much lead is present, it will be at once re-precipitated as chloride. In this case, pour off a portion of the supernatant liquid. (See *b.*)

a. To prove the presence of lead, add water to the precipitate, and dissolve by the aid of heat. Plumbic chloride will crystallize on cooling, as represented in Fig. 3, Plate I.

b. Evaporate the solution at a very gentle heat (about 50° C). Cupric chloride will crystallize first in long, branching needles (Fig. 4, Plate I), considerably coarser than those of Cadmium chloride, which is deposited next in bunches of fine radiating needles and hexagons, (Fig. 5, Plate I). Many of the latter have incurved sides, and these seem to be quite distinctive.

Sometimes the convexity is outwards, and then the outline of the crystal often approaches that of a circle. When only perfect hexagons are seen, these cannot be distinguished with certainty from those of bismuth chloride (Fig. 6, Plate I); although the latter, being somewhat deliquescent, require more time for their formation, and are often the centres of radiating, acicular bunches.

In the presence of Bismuth chloride, the existence of Cadmium should be verified by forming its double chloride with potassium, (Fig. 7, Plate I). By evaporating a drop of the solution, simply placed in contact with one of potassic chloride solution without stirring, the crystals of double chloride appear only on the dividing line, as in Fig. 8, Plate I.

III. Dissolve a portion of the precipitated carbonates in acetic acid. The carbonate of copper dissolves quickly with effervescence, and, if in large quantity, is at once deposited again in beautiful, deep blue crystals of the monoclinic system (Fig. 9, Plate I), often forming twins, which fall in heaps in the track of a stirring rod. The other carbonates dissolve quite slowly ; and, being very deliquescent, do not crystallize when the solution is evaporated at a gentle heat.

Scheme for distinguishing Barium, Strontium and Calcium, in presence of each other :

Precipitate the group by ammonic carbonate. Wash and dissolve the precipitate in chlorhydric acid.

I. Let a drop of the solution evaporate spontaneously. The chlorides of Barium, Strontium and Calcium can often be recognized in this way. The chloride of calcium crystallizes in large, radiating prisms with oblique ends, (Fig. 10, Plate I). It is a beautiful sight to see the finer, moss-like forms of strontic chloride (Fig. 11, Plate II), creeping across the field, or the more branching, dendritic crystals of baric chloride, which often come down in four or six-rayed stars, as do these of strontic chloride occasionally. The latter, however, generally forms a 60° cross, while baric chloride has the arms more frequently at an angle of 90°, and more profusely branched. But there is nothing very definite in these, and we have seen the greatest variety in the crystallization of baric chloride of any substance tried.

II. To another drop of the solution add alcohol. Baric chloride comes down in dense heads (Fig. 12, Plate II), reminding one of the ripe heads of dandelions, although the resemblance would not hold good when minutely examined. The first precipitate is sometimes followed by bundles of irregular plates, (Fig. 13, Plate II).

In the absence of calcium, alcohol precipitates chloride of strontium in fine needles, separate, and also in stellate bunches, (Fig. 14, Plate II). These soon dissolve as the alcohol evaporates, and are succeeded by rhombuses.

Fig. 11
× 25

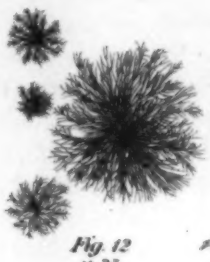

Fig. 12
× 25

Fig. 13.

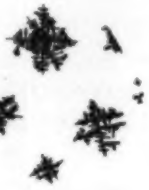

Fig. 2.
× 25

Fig. 14. × 25

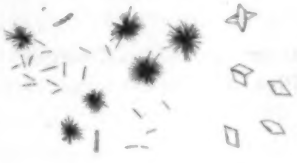

Fig. 16.
× 100

Fig. 15. × 25

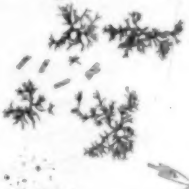

Fig. 19.
× 100

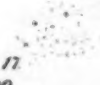

Fig. 17
× 100

Fig. 22. × 25

Fig. 18.
× 25

Fig. 20.
× 100

Fig. 21.
× 25

Fig. 23.
× 100

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Calcic chloride is not precipitated by alcohol.

III. Dilute a portion of the solution, and add ammonic oxalate (1-1000 N. S.). It is necessary to wait a short time for this reaction, as the first precipitate is very finely divided, but is gradually succeeded by another one, which is much coarser, particularly in the case of barium. The first finely divided precipitate of baric oxalate will entirely disappear in the course of ten or fifteen minutes, and will be succeeded by branching forms (Fig. 15, Plate II), looking sometimes like a deer's antlers. Strontium is precipitated in pointed crosses (Fig. 16, Plate II), while the oxalate of calcium (Fig. 17, Plate II) is too fine to be recognized with a $\frac{1}{4}$ objective.

Add enough chlorhydric acid to the precipitated oxalates to dissolve them. Then neutralize with dilute ammonia water. The oxalates will be thrown down again, but will have a slightly different aspect, as represented in Figures 18, 19 and 20, Plate II.

IV. An alcoholic solution of picric acid produces a precipitate in the aqueous solution of the chlorides, for the picrates of this group are all insoluble in alcohol. However, the picrates of barium (Fig. 21, Plate II) and of strontium (Fig. 22, Plate II) differ only in size; and the feathery picrate of calcium (Fig. 23, Plate II) does not always come down with sufficient clearness to be distinguished.

V. In the reactions which we have tried thus far, calcium has given the finest precipitates, and the ones most difficult to recognize. All this is reversed when we come to the sulphates. The precipitates of baric and strontic sulphates are too fine to be recognized, while sulphate of calcium forms large, radiating, acicular bunches, something like those in Fig. 14, Plate II, but much thicker. To obtain these, dilute sulphuric acid (1-100 N. S.) is added to the solution of the chlorides. The sulphate of calcium will not come down at once, if the solution contains but little calcium. Upon evaporation, however, the crystals will appear. In the presence of much barium and strontium, it may be necessary to use a more dilute solution, so that the dense cloud produced by the very minutely divided sulphates of these elements, may not obscure the calcic compound.

In conclusion, it may be remarked, that the value of these methods has been tested by the successful analysis of such solutions as would occur in practice.

FREEZING MIXTURES.*

The numerous and varied applications which ice has found in these times have greatly enhanced the importance of that product, and, while large portions of it have annually been transported from the colder to the hotter regions of the globe, scientific ingenuity has attacked, energetically and successfully, the problem of producing cold by artificial means for industrial and other purposes. In a recent number of *Dingler's Polytechnisches Journal*, Professor Meidinger has an instructive paper, giving an account of the progress made in recent years in the art of ice manufacture.

There are three ways indicated by physics in which temperature may be lowered, and ice formed—viz: solution of solid substances, evaporation of liquids, and expansion of gases. The following is an abstract of that portion of Professor Meidinger's paper relating to production of *cold by solution:*

Heat is absorbed by bringing solids to the liquid condition; and the cold thus produced may prove sufficient to convert water into ice.

The best known of the numerous freezing mixtures that have been hitherto described is, of course, one involving ice itself; it consists of 3 parts of ice, and 1 part of ordinary salt.

Dissolving concurrently, these two substances give a temperature of —21° C.† (the freezing point of the solution). The melting of only a part of the mixture is sufficient to produce this temperature throughout the mass; and with constant admission of heat, and stirring, the low temperature is maintained till the whole is dissolved. The freezing apparatus of confectioners is well known; a tin pot containing cream, a wooden or metallic vessel inclosing the pot, and the interval filled with ice and salt, which is frequently stirred, that the ice may not sink to the bottom. In a Paris machine, for home use, the agitation of the freezing mixture is maintained by rotation of the double cylinder containing it and the cream vessel, round an axis at right angles to the cylinder's length. Prof. Meidinger has constructed a machine based on the observation that a solution of ordinary salt under 0° also fuses ice, and, so long as its concentration is maintained, produces the same low temperature as the mixture of salt and ice. He provides a sieve-like vessel, containing salt, to maintain the con-

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* From *English Mechanic and World of Science*, December 31st, 1875.

† All the quantities of heat, weight, etc., in this article, are in French measures.

centration as the ice melts. The lowering of temperature is uniform throughout the vessel, and no stirring is required. The machine has come largely into use in perfumery.

On the basis of his own experiments, Professor Meidinger has formed a table showing the respective merits of various freezing mixtures. The following extract contains the most serviceable :—

Mixture.	Decrease of Temperature.	Specific heat of the solution.	Volume weight of the solution.	Loss of heat units.		To use for 120 c.		
				1 k. Mixture.	1 l. Mixture.	Salt k.	Water k.	Cost in Marks.
1 ordinary salt, 3 ice...	21°	0·83	1·18	125	100	0·5	1·5	0·34to0·12
3 cryst. Glauber salt, 2 concentrated muriatic acid.....	37°	0·74	1·31	55	74	2·7	1 8	1·0 to 0·6
2 nitrate of ammonia, 1 sal-ammoniac, 3 water.....	30°	0·70	1·20	42	51	3·	3·	7·6 to 6·8
3 sal-ammoniac, 2 saltpetre, 10 water...	26°	0·76	1·15	40	46	2·1	4·2	2·6 to 2·2
3 sal-ammoniac, 2 saltpetre, 4 cryst. Glauber salt, 9 water.	32°	0·72	1·22	50	61	2·5	2·5	1·8 to 1·6

Salt mixtures give much greater lowering of temperature than simple salts, as they dissolve in much less water. Thus, 1 part sal-ammoniac is dissolved in three parts water, and lowers the temperature about 19° ; saltpetre dissolves in 6 parts water, and lowers the temperature about 11°. (Compare the fourth and fifth on the list.) It will be seen that the salt-ice mixture proves considerably more energetic and cheaper than any of the others so far as use of the materials only once is concerned. The second mixture, too, cannot be restored; nor can the last, easily, on account of the crystallized Glauber salt. Both are comparatively cheap, however. The mixture in which, by vaporization of the solution, the salt is easily renewed in its original condition, nitrate of ammonia, and sal-ammoniac is so costly at the first, that it would not do to use it only once. This was the mixture employed in an apparatus first exhibited by M. Charles at the Paris Exhibition in 1867. The tin vessel containing the substance to be frozen is inclosed in a large wooden vessel containing the freezing mixture, and is furnished with screw wings, which stir the